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DYNAMIC PRESSURES AND PLATING RESPONSE IN A MEDIUM SPEED PLANING HULL

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DYNAMIC PRESSURES AND PLATING RESPONSE
IN A MEDIUM SPEED PLANING HULL

by

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(1952)

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(1952)

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CARLOS QUIÑONES LOPEZ, LIEUTENANT COMMANDER, CHILEAN NAVY

Escuela Naval de Chile
(1947)

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREES OF NAVAL ENGINEER AND MASTER OF SCIENCE

IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
June, 1959

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1959
BROOKS, R.

~~Thesis~~
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ABSTRACT

DYNAMIC PRESSURES AND PLATING RESPONSE IN A MEDIUM SPEED PLANING HULL

by

Richard B. Brooks, Robert T. Clark and Carlos Quinones-Lopez

Submitted to the Department of Naval Architecture and Marine Engineering on 26 May 1959 in partial fulfillment of the requirements for the degree of Naval Engineer and the degree of Master of Science in Naval Architecture and Marine Engineering.

The object of this investigation was to determine the response of the bottom plating of a forty foot, Mark one, Coast Guard Utility Boat to the dynamic pressures found in service. Two phenomena were considered, the pressures due to slamming in ahead seas and the response of the plating near the propellers to the dynamic effects of the propeller field.

An attempt was made to correlate the maximum pressures observed with the heave accelerations of the center of gravity of the boat. Since the boat operates in a "semi-planing" condition, 56% supported by dynamic force and 44% by buoyancy effects at full power, the problem is extremely complex and no useful correlation was found. However, the stagnation planing pressure was never exceeded during the tests. As far as can be determined from other test results available, this pressure forms an upper limit on the pressures which may be expected in service.

From the pressures recorded, it was determined that the longitudinal pressure distribution peaked sharply. However, as has been experienced by other experimenters, the exact location of the point of stagnation pressure was not found exactly.

The stress values in the panel having maximum slamming pressures show that for this boat, the proper edge condition for calculation of panel stress is that of simple support. There is also evidence that a small amount of membrane effect is present. For the maximum pressure recorded, the stress at the center of the forward panel was calculated to be greater than the yield strength of the material. This panel showed evidence of permanent set at the center.

The pressures in the area of the propeller field were found to be less than 2.5 psi and of a frequency equal to the propeller blade frequency.

The strains in the center of the after panel were recorded for 3 and 4-bladed propellers. The strain in both cases was found to be no greater than 75 micro inches per inch, and the frequency of vibration was equal to the propeller blade frequency. No significant increase of magnification factor was experienced in changing from 3 to 4-bladed propellers.

The failures in the after panels can be attributed to attachments to the panels which produce hard spots and introduce larger stresses than those caused by water pressure vibrations.

Thesis Supervisor: J. Harvey Evans
Title: Associate Professor of Naval Architecture

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the following who gave generously of their assistance:

Professor J. Harvey Evans of the Department of Naval Architecture and Marine Engineering, their thesis supervisor.

CDR C. G. Houtsma and the Officers of the Naval Engineering Section at Coast Guard Headquarters, Washington, D. C. for their help in obtaining the boat and test equipment and for their unfailing help and encouragement.

The Officers of the Naval Engineering Section and of the Captain of the Port Unit, First Coast Guard District, Boston, Massachusetts, for making available their facilities for the test program.

Professor W. M. Murray of the Department of Mechanical Engineering for his help in solving the groups problems in strain gage techniques.

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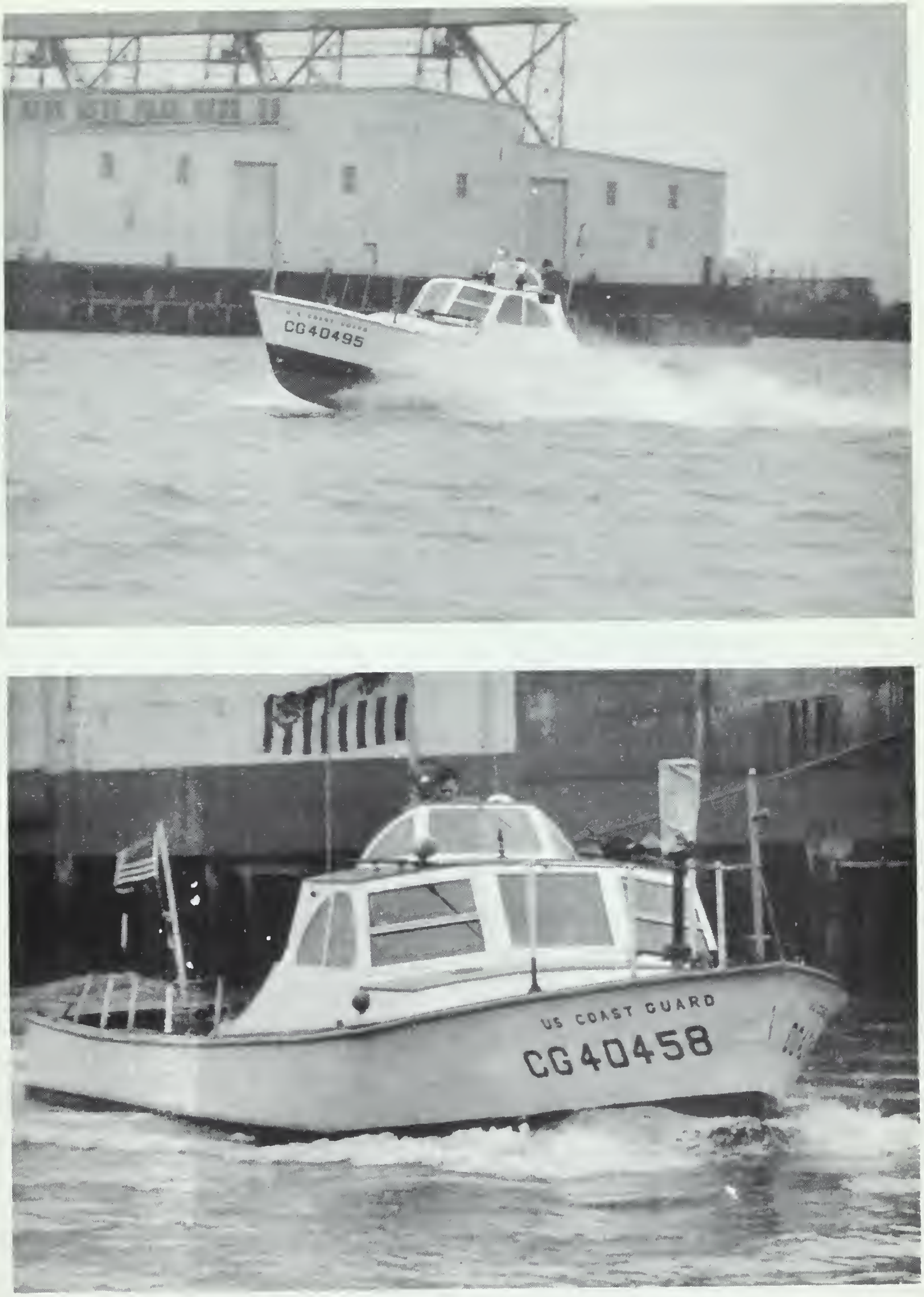

FIG. 1

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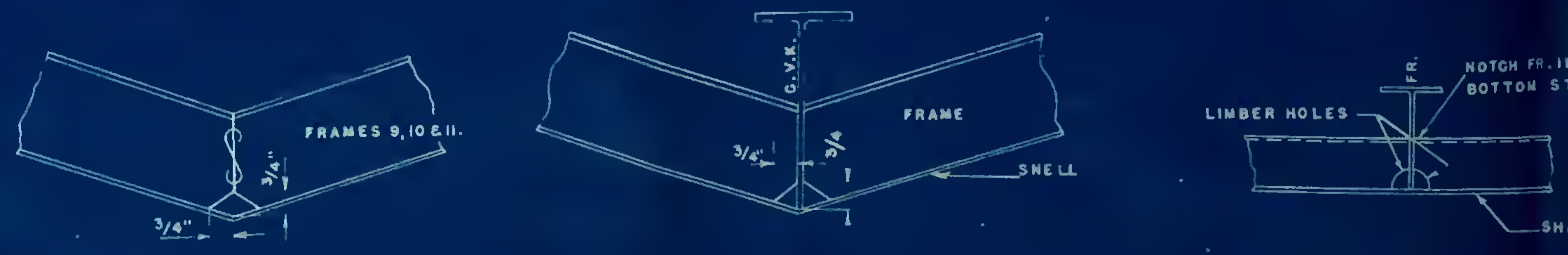
12 GA. DOUBLER UNDER CHOCK & CLEAT
8.1# R.
FOUNDATION FOR AN/URC-7 CONVERTER FOR DETAILS, SEE REF. NO. 12
MOULDED LINE OF DECK AT SIDE
FOR DETAILS - ANCH SEE REF. NO. 3.
8" MIN. AT BUTTS INBOARD EDGE STRAIGHT BETWEEN BUTTS
BOAT HOOK BRACKETS FOR DETAILS SEE REF NO.13
3'-9"
14"
EMERGENCY TILLER BR'KT.-P&S FOR DETAILS, SEE REF. NO. 13.
18# CO2 BOTTLE FOR BR'KT. DETAIL, SEE REF. NO.4.
DOOR
18"
18"
2" x 1/8" F.B.
18"
2" x 1/8" FLG.
12 GA.
2" x 1/8" FLG
FOR MATON DE PLAN 40'UT-1
2"x1/8" FLG.F.B.
1 1/2" STEM
12 GA. (U.S.S)
SEE DETAIL
DECK SCUTTLE - SEE PLAN 25'-10" M.S.B.-8232 G.S.Y.
FOR MATON DETAILS SEE PLAN NO: 40'UT-1802-2 MK-1
INSPECTION PLATE ON FLOOR FOR DETAILS SEE REF. NO.3.
2"x 1 1/2"x 3/16" ALUM ∠
2" x1/2" x 3/16 ALUM ∠
R. FLG'D. DOWN 1"
CUT IN CABIN TOP
COMPASS WELL SEE REF# 2.
INSPECTION R.
2"x 1 1/2" x 3/16" ALUM ∠
2" x 1/8" F.B.
24"
2" x 3" x 1/4" ∠ - GALV. STL.
5" x 1/4" F.B. UNDER
12 GA.(U.S.S.)
BOX
GALV. STEEL
2'-0"
2'-9"
28"
2"x1/2"x3/16" ∠ ALUM.
2'-0"
GUN LOCKER, SEE REF. NO.2
ENC. FOR MORSE CONTROLS, SEE REF. NO.2.
FOUND. MOTOROLA TRANS. SEE REF. NO. 11
12"
2" x 1/2" x 3/16" ∠ STEEL
FOR BOATS 40415 TO 40490 INCL. ONLY.
FOR BOATS 40391 TO 40414 INCL. ONLY.
2" x 3/16" F.B. ALUM
1 1/2" x 1/8" F.B. ALUM
1/8" ALUM FL. R.
2" x 2" x 3/16" ∠
2" x 3/16" F.B.
1 1/2" x 1/8" F.B.
12 GA. (U.S.S) STEEL
℄ SHAFT
1 1/2" x 1/8" ALUM. F.B.
FOR DETAILS OF ENGINE FOUNDATION SEE 40' UT-4502-1 MK 1.
1 1/2" x 1/8" F.B. STIFF. ALUM.
PIPE SUPPORT FOR DET. SEE REF. 10
CABINET
1 1/2" x 1/8" F.B. STIFF. ALUM.
1 1/2"x2" x 3/16"
2"x2"x3/16"
1 1/2"x2"x3/16"x.75" ALUM.
1/2" x 1/8" F.B.
12 GA. (U.S.S.) STEEL
12"
2"x2"x3/16" ∠
3/4" PIPE
1/8" ALUM. R.
2" X 1 1/2" X 3/16" ∠ ALUM.
TRANSOM SEAT FOR DETAILS SEE REF. NO. 1.
SEE FASTENING DETAIL CABIN FL. PLATE.
2" x 1/4" F.B. ALUM.
3" VENT P&S.
1 1/2" x 1/8" F.B.
10"X16" CLEAN OUT OPENING, P. & S.
ALUM. ANGLE OFFSET TO GO UNDER ALUM. R.
2"x2"x3/16" ∠
SHEER LINE
SEE DETAILS, TANK ENDS
FUEL OIL TANK & CLEANOUT FOR BOATS 40391 TO 40415 INCL.(ONLY)
FUEL OIL TANK & CLEANOUT FOR BOATS 40416 TO 40490 INCL.(ONLY) FOR DETAILS, SEE REF. NO.7 & 8.
STOKES STRETCHER BRACKET FOR DETAILS SEE REF. NO.15.
PORTABLE DECK PLATES, ALUMINUM FOR BOATS 40391 TO 40415 INCL.
FIXED DECK PLATES
PORTABLE DK. R. ALUM

PLAN VIEW

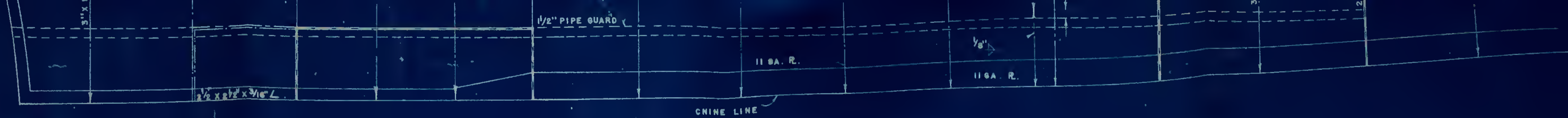
SCALE 3/4" = 1'-0"

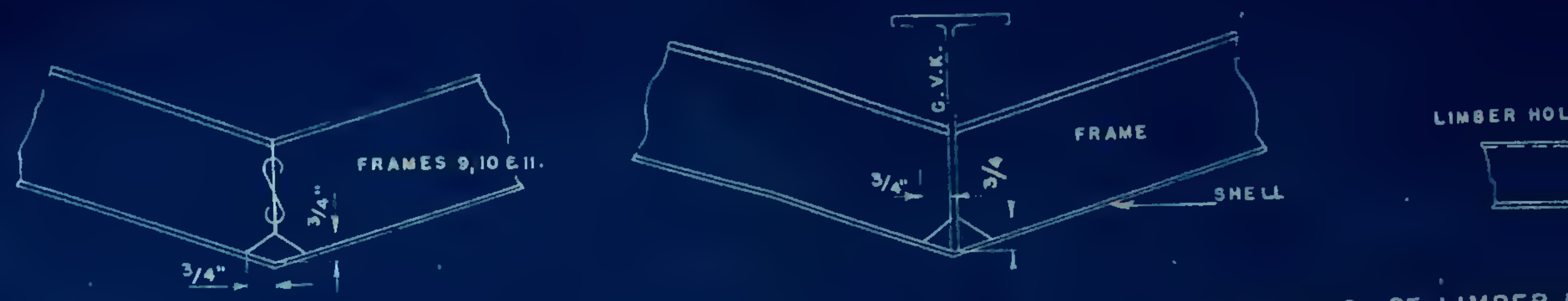


DETAILS OF LIMBER HOLES

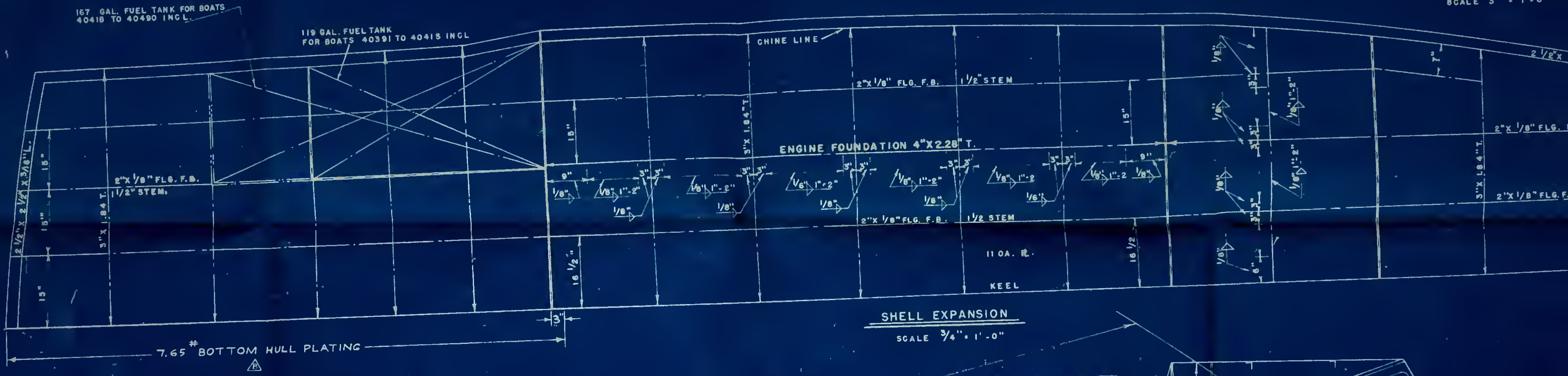
SCALE 3" = 1'-0"

167 GAL. FUEL TANK FOR BOATS 40416 TO 40490 INCL.
119 GAL. FUEL TANK FOR BOATS 40391 TO 40415 INCL
CHINE LINE
2" x 1/8" FLG. F.B.
1 1/2" STEM
1/8"
1'-2"
7"
2 1/2" x 1/8" F.B.





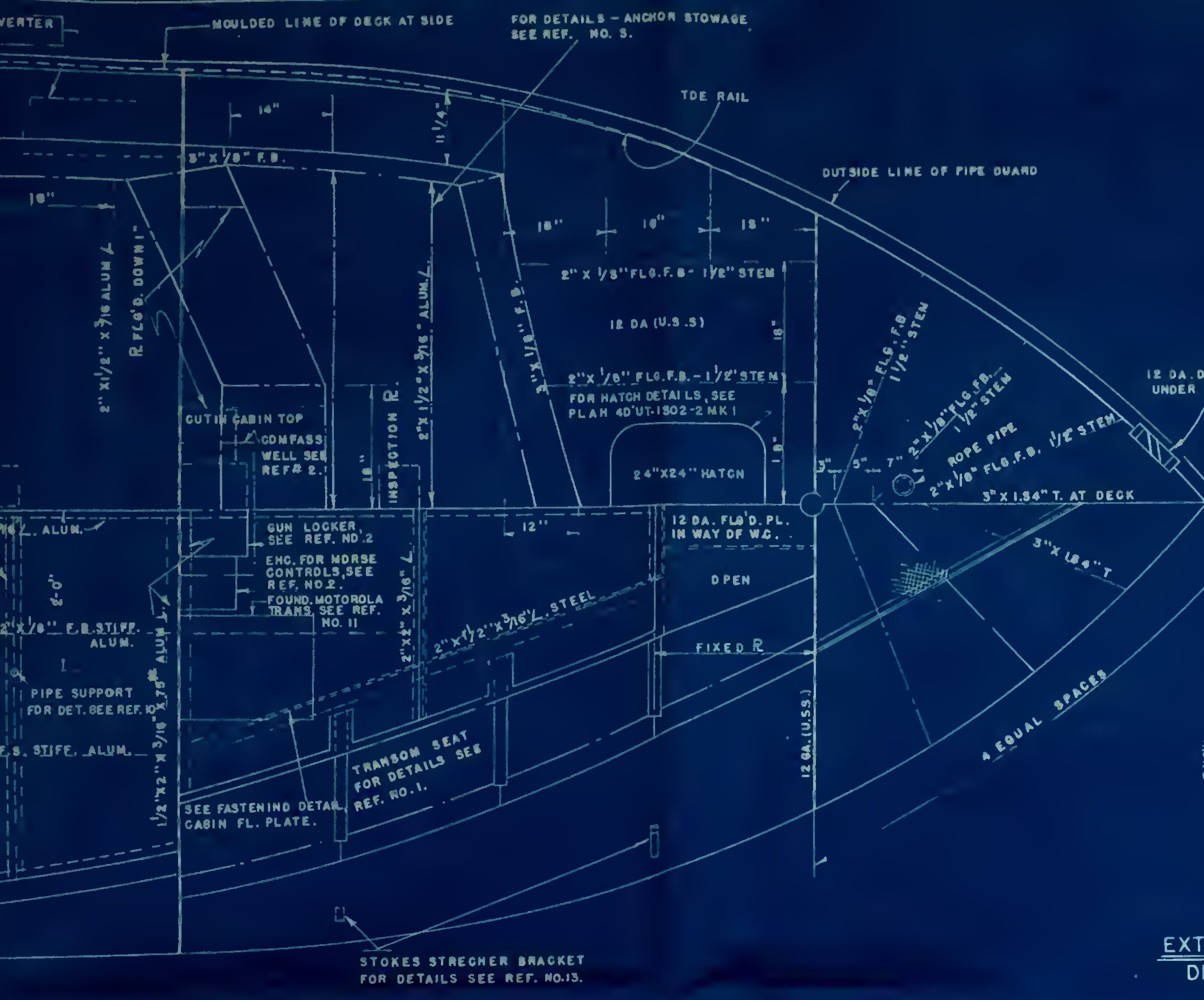
DETAILS OF LIMBER
SCALE 3" = 1'-0"


167 GAL. FUEL TANK FOR BOATS 40418 TO 40490 INCL.
119 GAL. FUEL TANK FOR BOATS 40391 TO 40415 INCL
CHINE LINE
2"x1/8" FLG. F.B.
1 1/2" STEM
ENGINE FOUNDATION 4"X2.28" T.
3"X 1.84" T
2"x1/8" FLG. F.B.
1 1/2" STEM.
2 1/2" x 2 1/2" x 3/16" L.
3"X 1.84" T.
11 GA. R.
KEEL
18"
15"
16 1/2"
3"
7.65# BOTTOM HULL PLATING

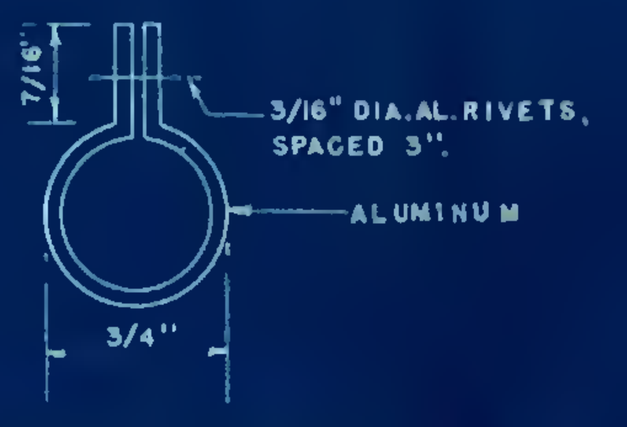
SHELL EXPANSION
SCALE 3/4" = 1'-0"

LIFTING SLING, FOR DETAILS SEE REF. NO. 9
OUTSIDE STEERING CONTROL BOX, FOR DETAIL - SEE REF. NO. 8.
15# CO2 BOTTLE FOR BRK'T. DETAILS, SEE REF. NO. 4.
BOX ENDS FLG'D. 1" 11 GA. (S & S) .091 ALUM.
3/4" EXTRUDED SHAPE SEE DETAIL
18" FROM STA. 10
WIRE MESH
15" OFF C P & S - 1 1/4" PIPE BRACES FOR DETAILS SEE 40UT 2200-2-MK 1
26 GA. GALV. DUCT
BOX - FOR DETAIL - SEE 40UT-1602-2 MK-1.
12 GA. (U.S.S.) R.
1/2" x 2" x 3/16" L. BUTT. WELD TO R.
1/8" ALUM FLOOR R.
3" x 3/16" ALUM. F.B.
3"x2"x1/4" L
3"-12 GA. F.B. COAMING WELDED TO DECK.
NON RETURN DRAIN VALVE
EMER. TILLER BRACKET, FOR DETAIL SEE REF NO. 13
9 1/2"
1/8" R CAP
3/4" PIPE 10" LG. ENDS PLUGGED.
TOWING BITT 3" STD. PIPE - .25" WALL.
1 1/4" PIPE
ENG. BOX DETAIL - SEE U.S.C.G. PLAN NO. 40 UT - 4106 - 1 - MK - 1.
2" x 1 1/2" x 3/16" ALUM L.
6'-8" INSIDE
BOAT HOOK BRACKET, FOR DETAIL, SEE REF. NO. 13.
FUEL TANK
SHAFT STRUT & SHAFT TUBE FOR DETAIL SEE PLAN 40 UT 4302-1 MK-1.
3/16 SOLE R. WELDED TO PIPE & WELDED TO C.V.K.
3" x 2 5/8" x 3/16" CHAN.
1 1/4" STD. PIPE
1 1/4" NON RETURN DRAIN VALVE
1 1/4" STD. PIPE
4" x 2.28 T.
T 8" X 3.06" X 5.9# T.
C SHAFT
1/2" LIMBER HOLE.
12 GA. R
DRILL 1/2" DIA. LIMBER HOLES
FRAME SPACING 2'-0"
LCG
26"
8 3/4"
2 1/2"
3'-10"
10 1/2"
1/8"
4'-0" R.
10"
12"
3"
6"
2 3/4"
6'-8"
3'-0"
3'-10" TO BASE LINE
3'-3"
30°
3'-2 1/2"
3" R.
21"
11"
3" R.
1/2" x 2" x 3/16" ALUM. L
11 GA (S & S) .091 ALUM L.
COMPASS WELL FOR DETAIL SEE REF. NO. 2.
FOUNDATION-MOTOROLA TRANS.-FOR DETAIL SEE NO. 11.
10"
3'-0"
GUN LOCKER ENC., MORSE CONTROL
FOUNDATION FOR AN/URC-7 CONVERTER FOR DETAILS, SEE REF. NO. 12.
TRANSOM SEAT, FOR DETAIL
INSPECTION PLATE
1/4" ALUM. FLOOR R.
1/2" x 2" x 3/16" L
INSPECTION PLATE SEE REF. NO. 5
PIPE SUPPORT SEE REF. NO. 10.
DRILL 1/2" DIA. LIMBER HOLES
T 6" x 3.06" x 5.9# T.
2"
ENTRY 1950 RPM
2'-0" FRAME SPACING TO BHD. 12.
10
17
9
16
15
14
6
13
12
7
11
10
6
9
8
5
7
4
6
5
3
4
3
2

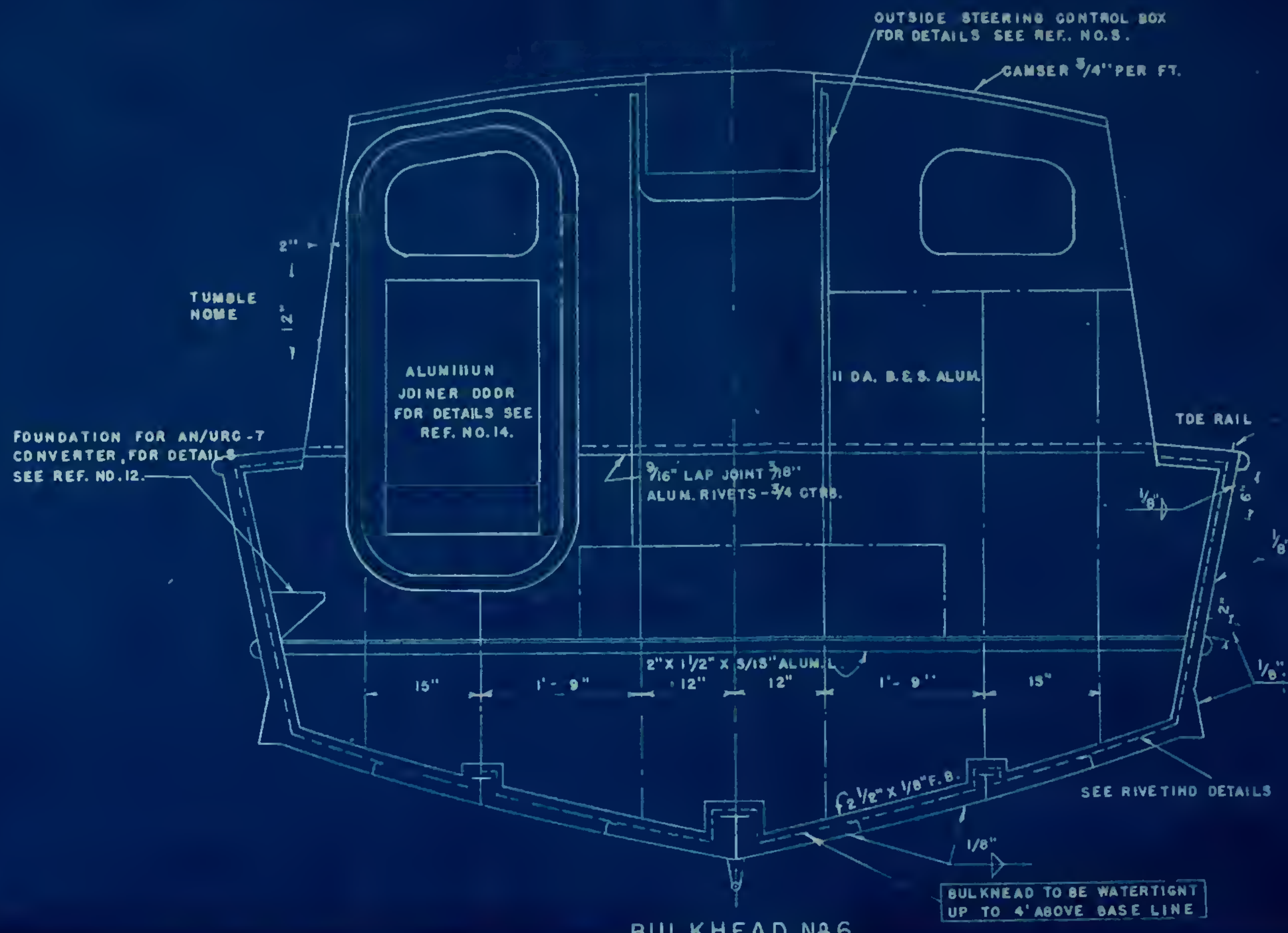
PROFILE
SCALE 3/4" = 1'-0"



VERTER
MOULDED LINE OF DECK AT SIDE
FOR DETAILS - ANCHOR STOWAGE SEE REF. NO. 3.
TOE RAIL
OUTSIDE LINE OF PIPE GUARD
3"x 1/8" F.B.
14"
11 1/4"
16"
18"
16"
18"
2"x 1/8" FLG.F.B - 1 1/2" STEM
12 DA (U.S.S)
2"x 1/8" FLG.F.B. - 1 1/2" STEM
FOR HATCH DETAILS, SEE PLAN 40'UT-1502-2 MK I
24"x24" HATCH
2"x 1/8" FLG. F.B. 1 1/2" STEM
2"x 1/8" FLG.F.B. 1/2" STEM
ROPE PIPE
2"x 1/8" FLG.F.B. 1/2" STEM
3"x 1.54" T. AT DECK
12 DA. DOUBLER UNDER GNDCK
2"x1/2"x3/16 ALUM. L
R FLOO. DOWN
CUTIN CABIN TOP
COMPASS WELL SEE REF. 2.
INSPECTION R
2"x 1 1/2"x 3/16" ALUM. L
3"x 1/8" F.B.
GUN LOCKER SEE REF. NO 2
ENC. FOR MORSE CONTROLS, SEE REF. NO 2.
FOUND. MOTOROLA TRANS. SEE REF. NO. 11
12"
12 DA. FLO'D. PL. IN WAY OF W.C.
OPEN
FIXED R
3"x 1.54" T
ALUM.
2'-0"
2"x 1/8" F.B. STIFF. ALUM.
PIPE SUPPORT FOR DET. SEE REF. 10
F.S. STIFF. ALUM.
2"x 2"x 1/2"x 3/16" L STEEL
12 GA. (U.S.S)
4 EQUAL SPACES
TRANSOM SEAT FOR DETAILS SEE REF. NO. 1.
SEE FASTENING DETAIL CABIN FL. PLATE.
STOKES STRECHER BRACKET FOR DETAILS SEE REF. NO. 13.

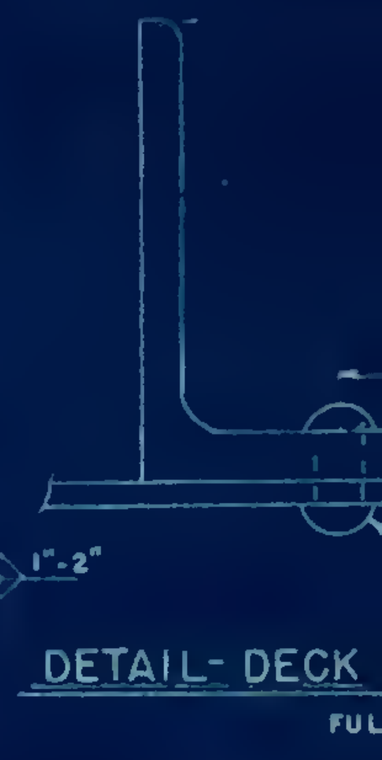


EXTRUDED SHAPE
DIE Nº 4477
FULL SIZE

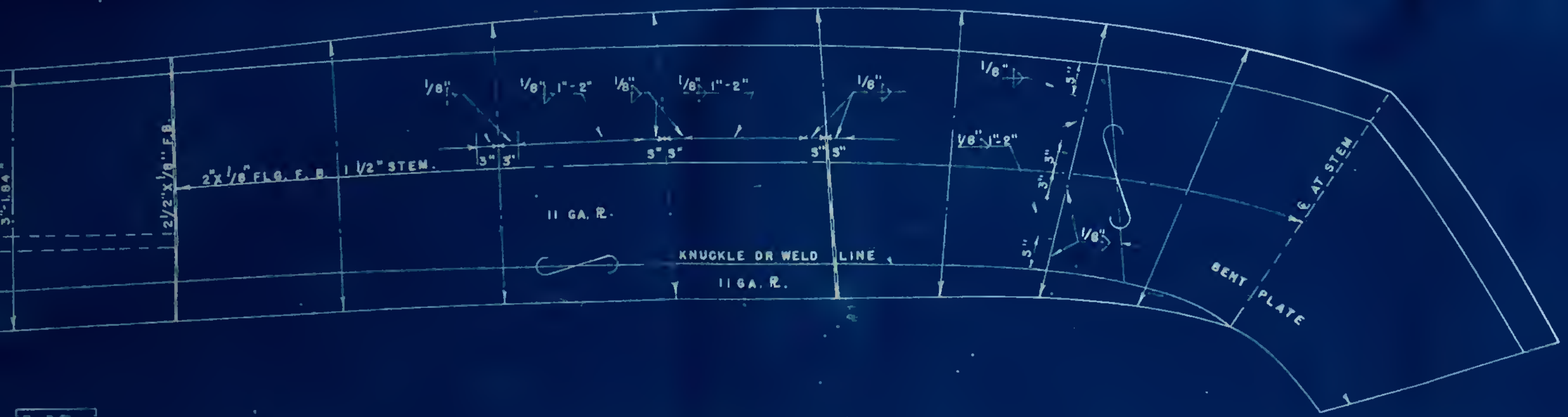


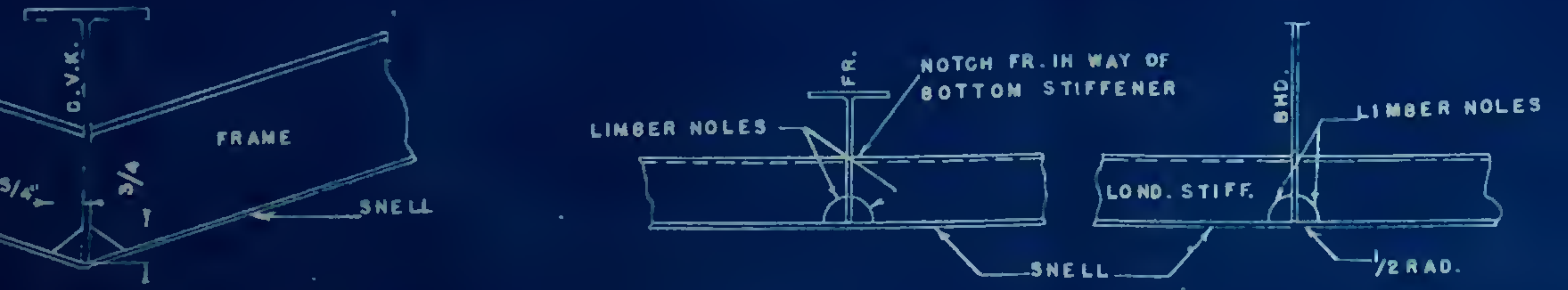
OUTSIDE STEERING CONTROL BOX FOR DETAILS SEE REF. NO. 5.
CAMBER 3/4" PER FT.
TUMBLE HOME
2"
12"
ALUMINUM JOINER DOOR FOR DETAILS SEE REF. NO. 14.
11 DA. B.& S. ALUM.
TOE RAIL
FOUNDATION FOR AN/URC-7 CONVERTER, FOR DETAILS SEE REF. NO. 12.
9/16" LAP JOINT 5/16" ALUM. RIVETS - 3/4 CTRS.
1/8"
2"x 1 1/2" x 3/16" ALUM. L
15"
1'- 9"
12"
12"
1'- 9"
15"
2 1/2"x 1/8" F.B.
SEE RIVETING DETAILS
1/8"
BULKHEAD TO BE WATERTIGHT UP TO 4' ABOVE BASE LINE

BULKHEAD Nº 6
LOOKING FOR'D.

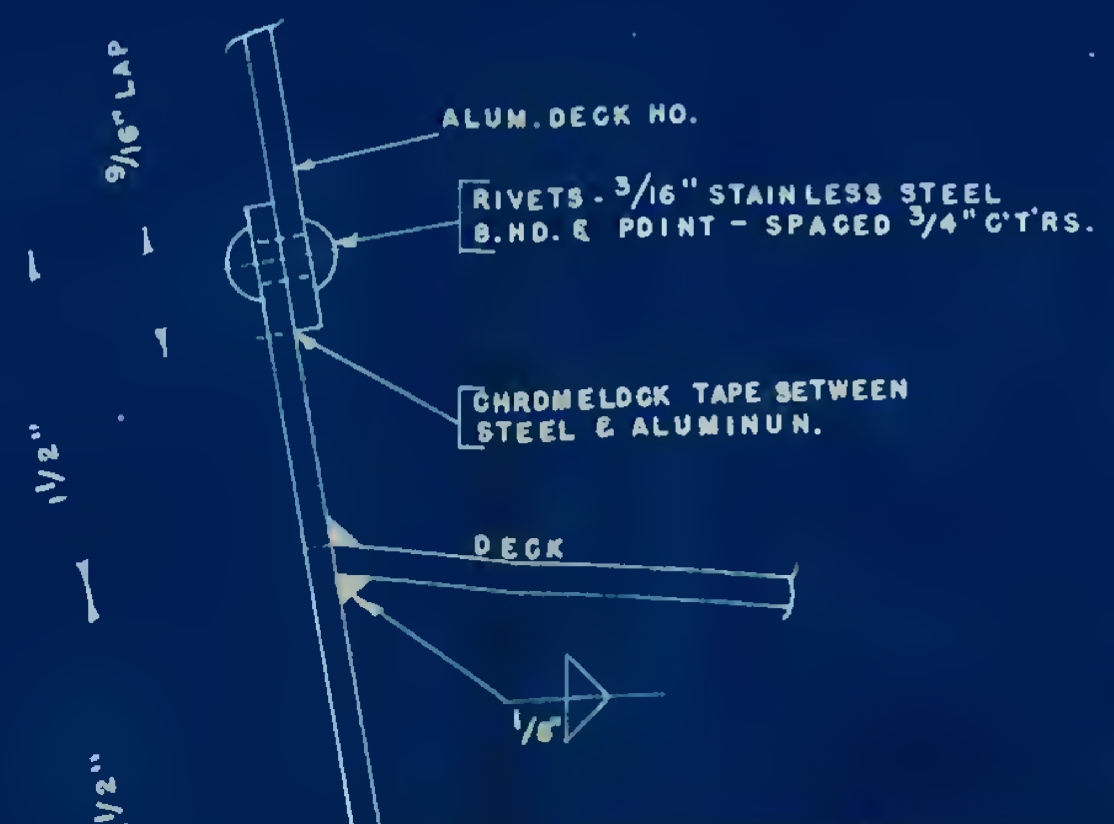


DETAIL- DECK
FUL



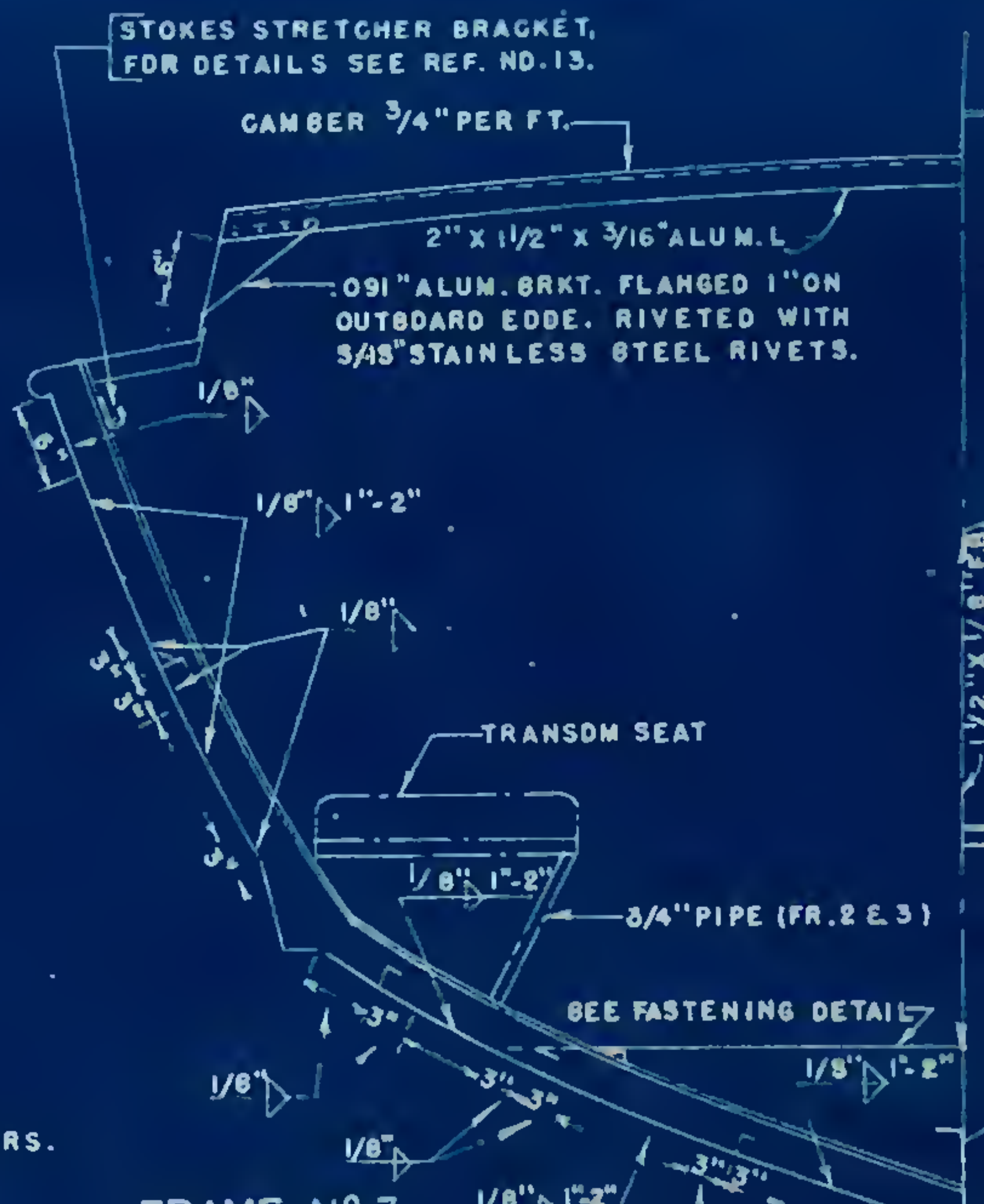


DETAILS OF LIMBER HOLES
SCALE 3" = 1'-0"



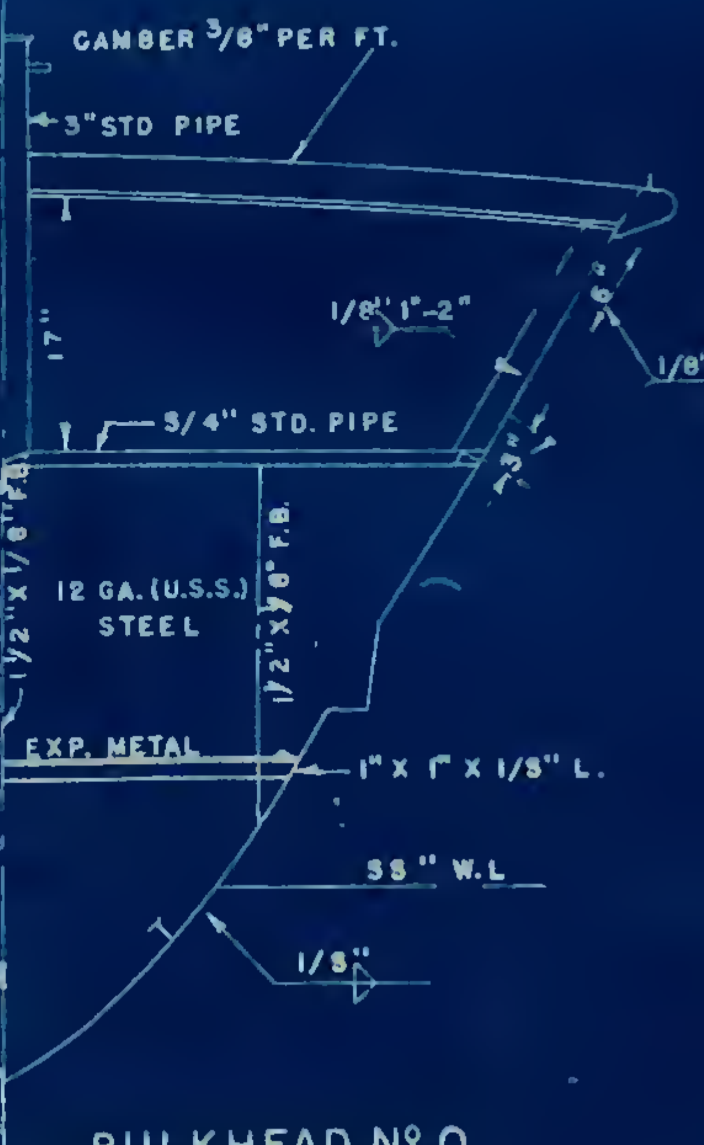
9/16" LAP
ALUM. DECK HO.
RIVETS - 3/16" STAINLESS STEEL B.HD. & POINT - SPACED 3/4" C'T'RS.
CHROMELOCK TAPE BETWEEN STEEL & ALUMINUN.
1/2"
DECK
1/8"
1/2"

DETAIL- DECKHOUSE FASTENING
SCALE: FULL SIZE

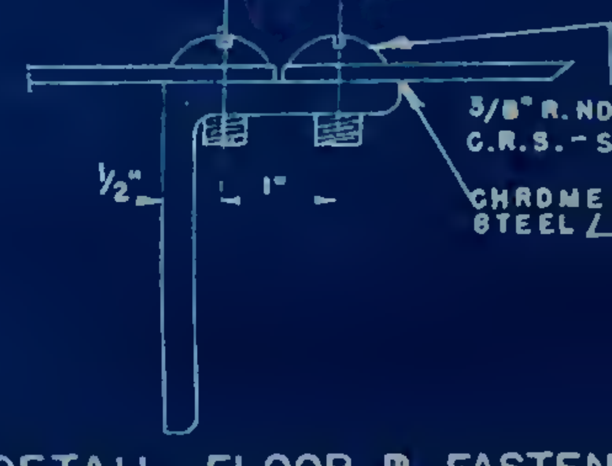


STOKES STRETCHER BRACKET, FOR DETAILS SEE REF. NO. 13.
CAMBER 3/4" PER FT.
2"x 1 1/2"x 3/16" ALUM. L
.091" ALUM. BRKT. FLANGED 1" ON OUTBOARD EDGE. RIVETED WITH 3/16" STAINLESS STEEL RIVETS.
1/8"
1/8" 1"-2"
1/8"
TRANSOM SEAT
1/8" 1"-2"
3/4" PIPE (FR. 2 & 3)
SEE FASTENING DETAIL
1/8" 1"-2"
1/8"
1/8"
1/8" 1"-2"
1/8"

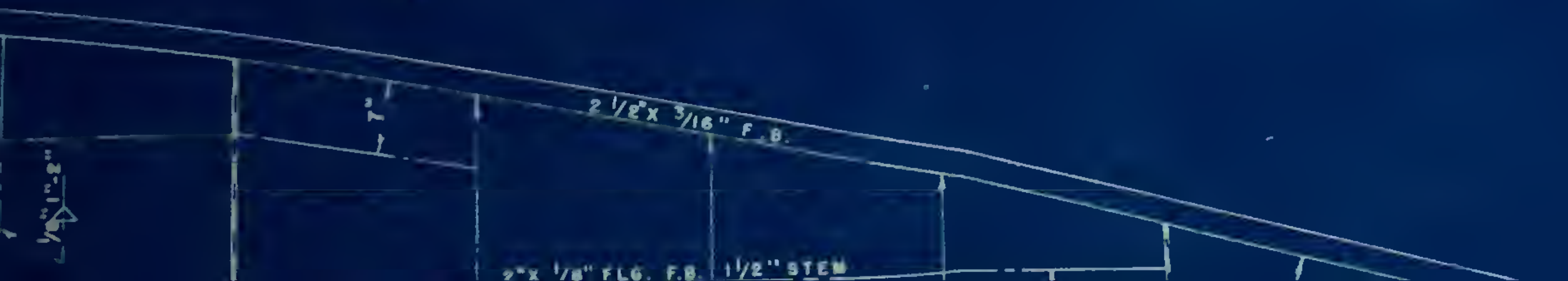
FRAME Nº 3

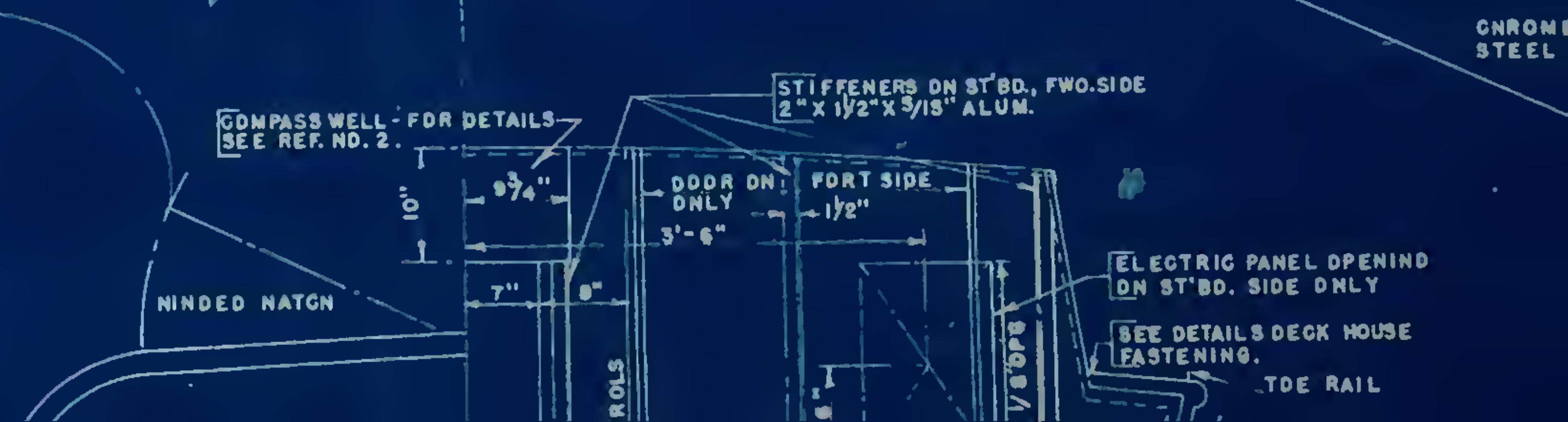


BULKHEAD Nº 0



DETAIL-FLOOR R. FASTEN
HALF SIZE

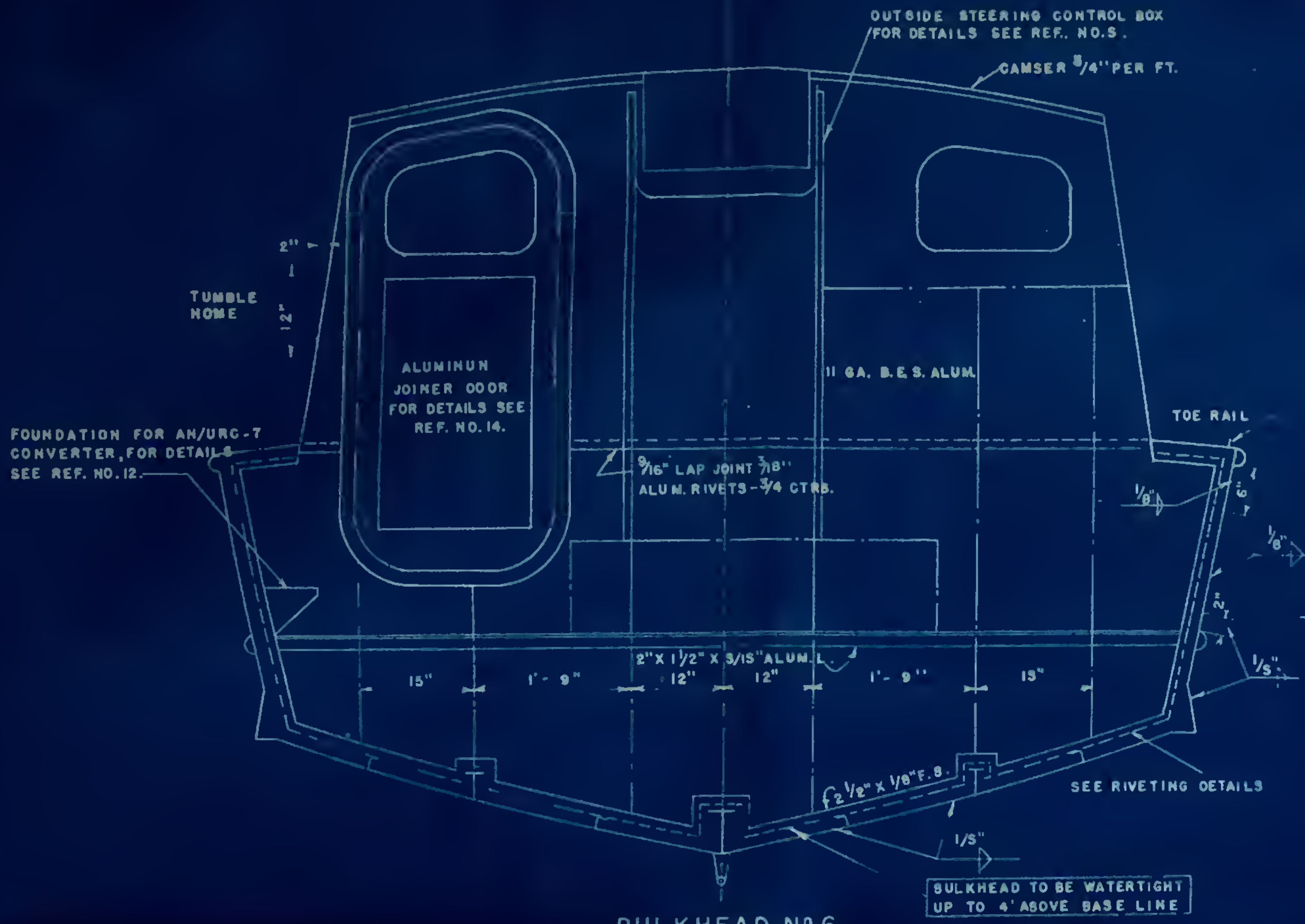




COMPASS WELL - FOR DETAILS SEE REF. NO. 2.
STIFFENERS ON ST'BD., FWD. SIDE 2"x 1 1/2"x 3/16" ALUM.
10"
9 3/4"
DOOR ON PORT SIDE ONLY
1/2"
3'-6"
7"
8"
HINGED HATCH
ELECTRIC PANEL OPENING ON ST'BD. SIDE ONLY
SEE DETAILS DECK HOUSE FASTENING.
TOE RAIL

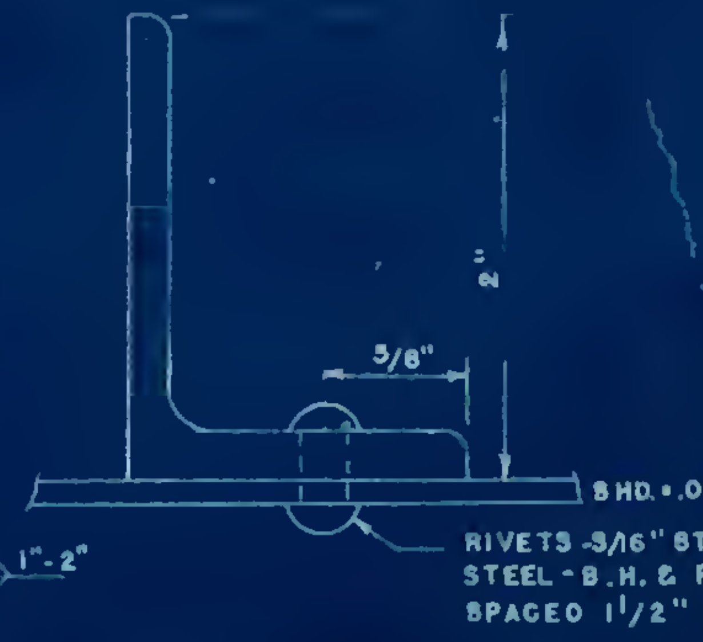
11 GA. R.
KNUCKLE OR WELD LINE
11 GA. R.
BENT PLATE
NOTCH FR. IN WAY OF BOTTOM STIFFENER
LIMBER HOLES
LIMBER HOLES
FRAME
SHELL
LONG. STIFF.
SHELL
1/2 RAD.
DETAILS OF LIMBER HOLES
SCALE 3" = 1'-0"
ALUM. DECK HD.
RIVETS - 5/16" STAINLESS STEEL B. HD. & POINT - SPACED 3/4" C'TRS.
CHROMELOCK TAPE BETWEEN STEEL & ALUMINUM.
DECK
DETAIL - DECKHOUSE FASTENING
SCALE: FULL SIZE
2 1/2" X 5/16" F.B.
2" X 1/8" FLG. F.B. 1 1/2" STEM
2" X 1/8" FLG. F.B. 1 1/2" STEM
3" X 1.84" T.
3" PIPE MOORING BITT
CLOSING PLATES 1/8"
45°
DETAIL - CLOSING PLATES
HALF SIZE
TRANSOM SEAT
3/4" PIPE (FR. 2 & 3)
SEE FASTENING DETAIL
FRAME Nº 3
3/4" STD. PIPE
12 GA. (U.S.S.) STEEL
EXP. METAL
1" X 1" X 1/8" L.
35" W.L.
BULKHEAD Nº 0
DETAIL - DK
FULL SIZE
3/8" R. HD. MACH. SCR. C.R.S. - SPACED 2 1/2
CHROME LOCK TAPE STEEL L & ALUM
DETAIL - FLOOR R. FASTENING ON
HALF SIZE
CHROME LOCK TAPE STEEL & ALUM. R
COMPASS WELL - FOR DETAILS SEE REF. NO. 2.
STIFFENERS ON ST'BD. FWD. SIDE 2" X 1 1/2" X 3/16" ALUM.
DOOR ON PORT SIDE ONLY
HINGED HATCH
ELECTRIC PANEL OPENING ON ST'BD. SIDE ONLY
SEE DETAILS DECK HOUSE FASTENING.
TOE RAIL
GUN LOCKER
ENC. FOR MORSE CONTROLS
3/4" DIA. EXTRUDED SHAPE - DIE NO. 4477.
12 1/8" OPG.
SEE RIVETING DETAIL
SEE DETAIL SPRAY SHIELD
1 1/2 FLG.
3/4" PIPE AT FR. 9
AT FRS. 8 & 10.
2 5/8" X 3" X 3/16" L
11 GA. B & S ALUM.
4' TO BASE LINE
36" W.L.
2'-8" W.L.
BULKHEAD TO BE WATERTIGHT UP TO 4' ABOVE BASE LINE
FRAME Nº 10
LOOKING AFT
BHD. Nº 4
LOOKING AFT
LIMBER
DE
CAMBER 1/2" PER FT.
1/8" R. FLANGED 1 1/2"
EMER. TILLER BRK'T. SEE REF. # 13.
℄ SHAFT
11 GA. (U.S.S.) STEEL
3/4" PIPE
2 1/2" X 2 1/2" X 3/16" L.
FRAME Nº 15.
TRANSOM
EXPANDED
STIFFENERS CUT FROM 6" J.I. BEAMS.
PLUG WELDS - 1/4" HOLES AT 2" CTRS.
12 GA.
3/4" ROD
TYPICAL SKEG DETAIL
11 GA. (U.S.S.)
CHINE DETAIL - AFT OF FR. 10
HALF SIZE
COMPASS WELL FOR DETAIL SEE REF. NO. 2.
FOUNDATION - MOTOROLA TRANS. - FOR DETAIL SEE REF. NO. 11.
1/8" R. CAP.
3/4" PIPE 10" LG. ENDS PLUGGED.
SEE DETAIL
3" STD. PIPE
3/4" PIPE
GUN LOCKER ENC., MORSE CONTROL
FOR DETAIL, SEE REF. NO. 2.
ION FOR AN/URC-7 CONVERTER AILS, SEE REF. NO. 12.
TRANSOM SEAT, FOR DETAILS, SEE REF. NO. 1.
1 1/2" X 1 1/2" X 1/8"
INSPECTION PLATE FOR DETAIL SEE REF. NO. 5
1/8" ALUM. FLOOR R.
PIPE SUPPORT SEE REF. # 10.
DRILL 1/2" DIA. LIMBER HOLES
6" X 3.06" X 5.9 # T.
10 GA. EXP. MET. PORTABLE
12 GA. (U.S.S.)
CHINE
FILL SPACE BET. 1" L. & SHELL WITH 12 GA. R.
STATIC DRAFT IN FULL LOAD TEST CONDITION
56" W.L.
ENTRY 1950 RPM
2'-0" FRAME SPACING TO BND. 12.
OBSERVED PLANING W.L. AT 1950 RPM
MEAN PLANING W.L. AT 1950 RPM
BASE LINE
FRAMES STATIONS

REF. NO.	TI
1	ARR'GT. & DE IN FWD. CO
2	ARR'GT. & DE ENCL. & GU
3	ARR'GT. & DET
4	LOCATION C
5	DET. OF INSP H'SE & LIT
6	ARR'GT. & D OUTSIDE ST
7	FUEL OIL TA FR. NO. 12.
8	DETAILS-CLE OIL TANKS.
9	LIFTING S
10	ARR'GT. & D AT FR. 9.
11	FOUNDATION
12	FOUNDATION
13	ARR'GT. & DE STOWAGE BR
14	ARR'GT & D IN BND. 8.


OUTSIDE STEERING CONTROL BOX FOR DETAILS SEE REF. NO.S.
CAMSER 3/4" PER FT.
2"
TUMBLE HOME
12"
ALUMINUN JOINER DOOR FOR DETAILS SEE REF. NO. 14.
11 GA. B.& S. ALUM.
TOE RAIL
FOUNDATION FOR AN/URC-7 CONVERTER, FOR DETAILS SEE REF. NO. 12.
9/16" LAP JOINT 3/16" ALUM. RIVETS - 3/4 CTRS.
1/8"
6"
1/8" 1"-2"
2" X 1 1/2" X 3/16" ALUM. L
15"
1'- 9"
12"
12"
1'- 9"
15"
1/S"
2 1/2" X 1/8" F.S.
SEE RIVETING DETAILS
1/S"
BULKHEAD TO BE WATERTIGHT UP TO 4' ABOVE BASE LINE

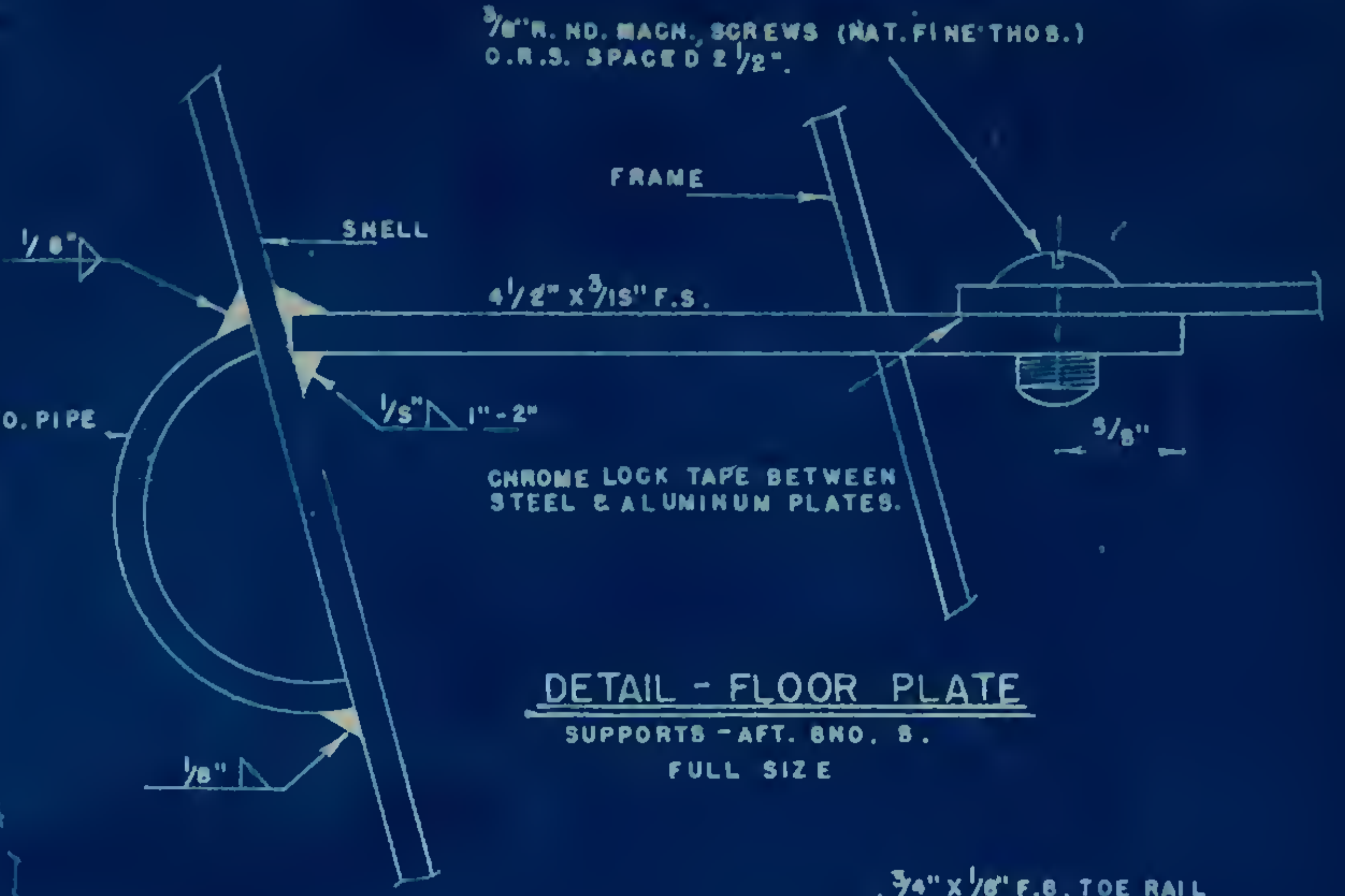
BULKHEAD Nº 6

LOOKING FOR'D.


5/8"
2"
BHD. = .061" ALUM.
RIVETS 3/16" STAINLESS STEEL - B.H. & POINT SPACED 1 1/2" CT'RS.

DETAIL- DECK HOUSE STIFFENERS

FULL SIZE


3/8" R. HD. MACH. SCREWS (NAT. FINE THDS.) C.R.S. SPACED 2 1/2".
FRAME
1/8"
SHELL
4 1/2" X 3/16" F.S.
HALF OF 1 1/2" STD. PIPE
1/S" 1"-2"
5/8"
CHROME LOCK TAPE BETWEEN STEEL & ALUMINUM PLATES.
1/8"

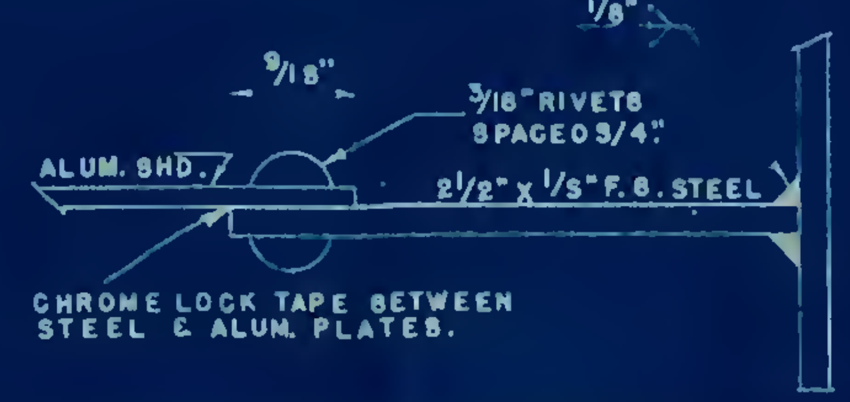
DETAIL - FLOOR PLATE

SUPPORTS - AFT. BHD. S.

FULL SIZE

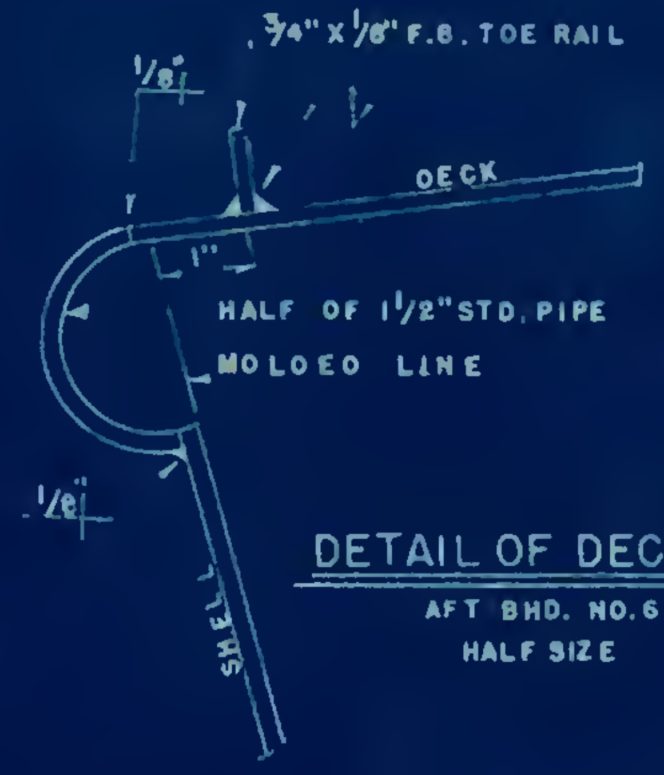
MATERIAL SPECIFICATIONS

	MATERIAL	NAVY SPECIFICATIONS
SHELL 11 GA. (U.S.S.) PL.	STEEL PLATE	47S-29 TYPE A CLASS b
FRAMES & BARS	ROLLED STEEL	46 S-1 TYPE B GRADE M
FLOOR PLATES 12 GA. (U.S.S.) " " 1/8"	ROLLED STEEL ALUMINUM	47 S-29 TYPE A CLASS b 47 A-12 CONDITION T
TUBING	STEEL-SEAMLESS ALUMINUM 61-S	44 T-1 TYPE 1 44 T-30
BULKHEADS 12 GA. (U.S.S.) 11 GA. (B.&.S.)	SHEET STEEL ALUMINUM 61-S	47 S-29 TYPE A CLASS b 47 A-12 CONDITION T
DECK HOUSE 11 GA (B. & S.)	ALUMINUM 61-S	47 A-12 CONDITION T
ENGINE BOX	ALUMINUM 61-S	47 A-12 CONDITION T
SKEG & TANKS 12 GA. (U.S.S.)	SHEET STEEL	47 S-29 TYPE A CLASS b


1/8"
9/16"
3/16" RIVETS SPACED 3/4".
ALUM. BHD.
2 1/2" X 1/S" F.S. STEEL
CHROME LOCK TAPE BETWEEN STEEL & ALUM. PLATES.

RIVETING DETAIL- BHDS. 4 & 6

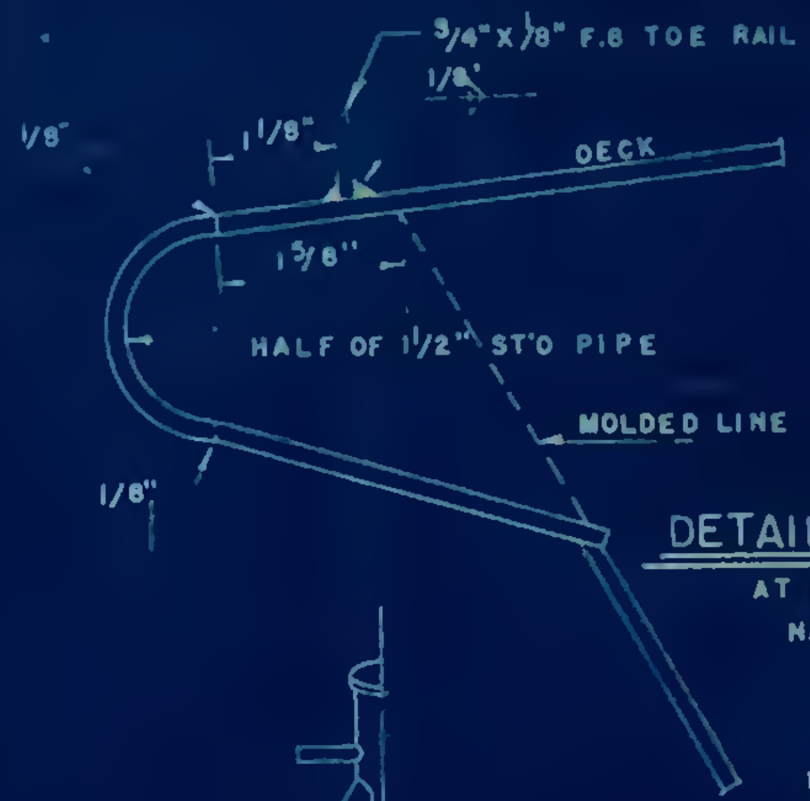
FULL SIZE



DETAIL OF DECK EDGE

AFT BHD. NO. 6

HALF SIZE

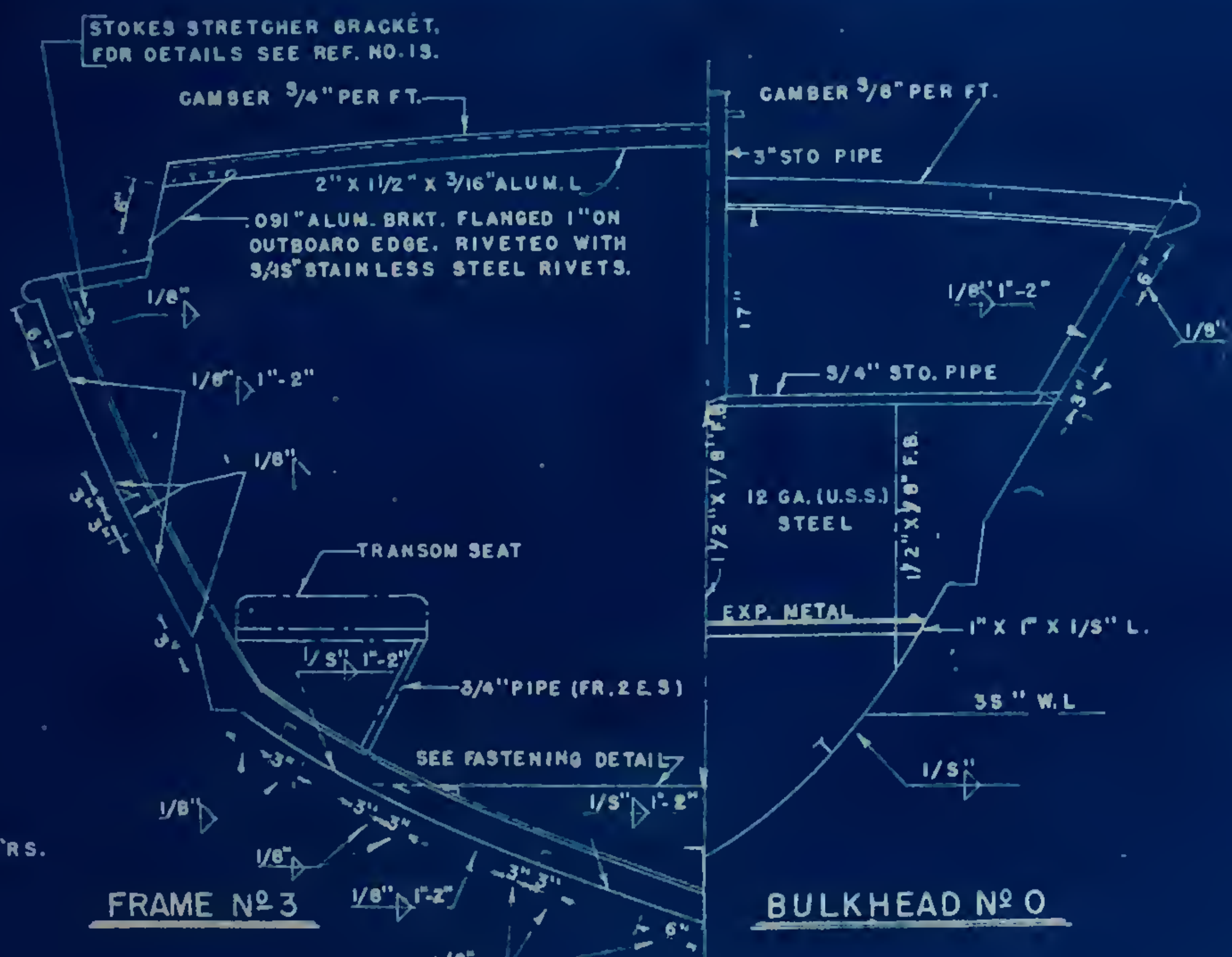


DETAIL OF DECK EDGE

AT BHD NO. 0

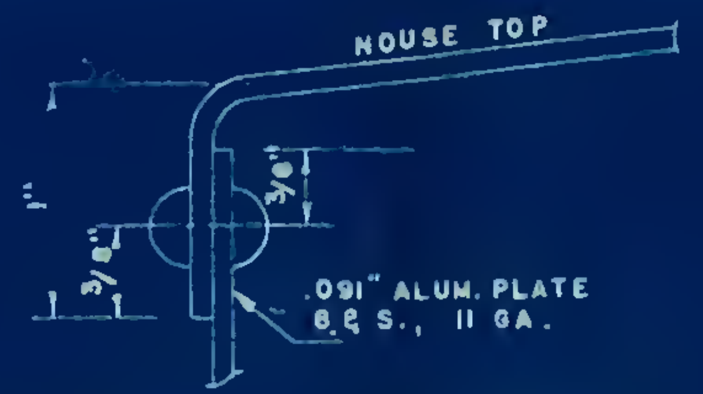
HALF SIZE

NOTE:-
FOR DETAILS AT OTHER FRAMES FOR'D. OF BHD. NO. 6, SEE PLAN NO. 40' UT - 1104-2-MK-1, MD. 1.



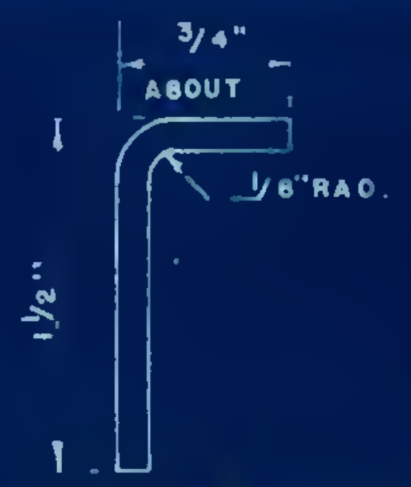
FRAME Nº 3

BULKHEAD Nº 0



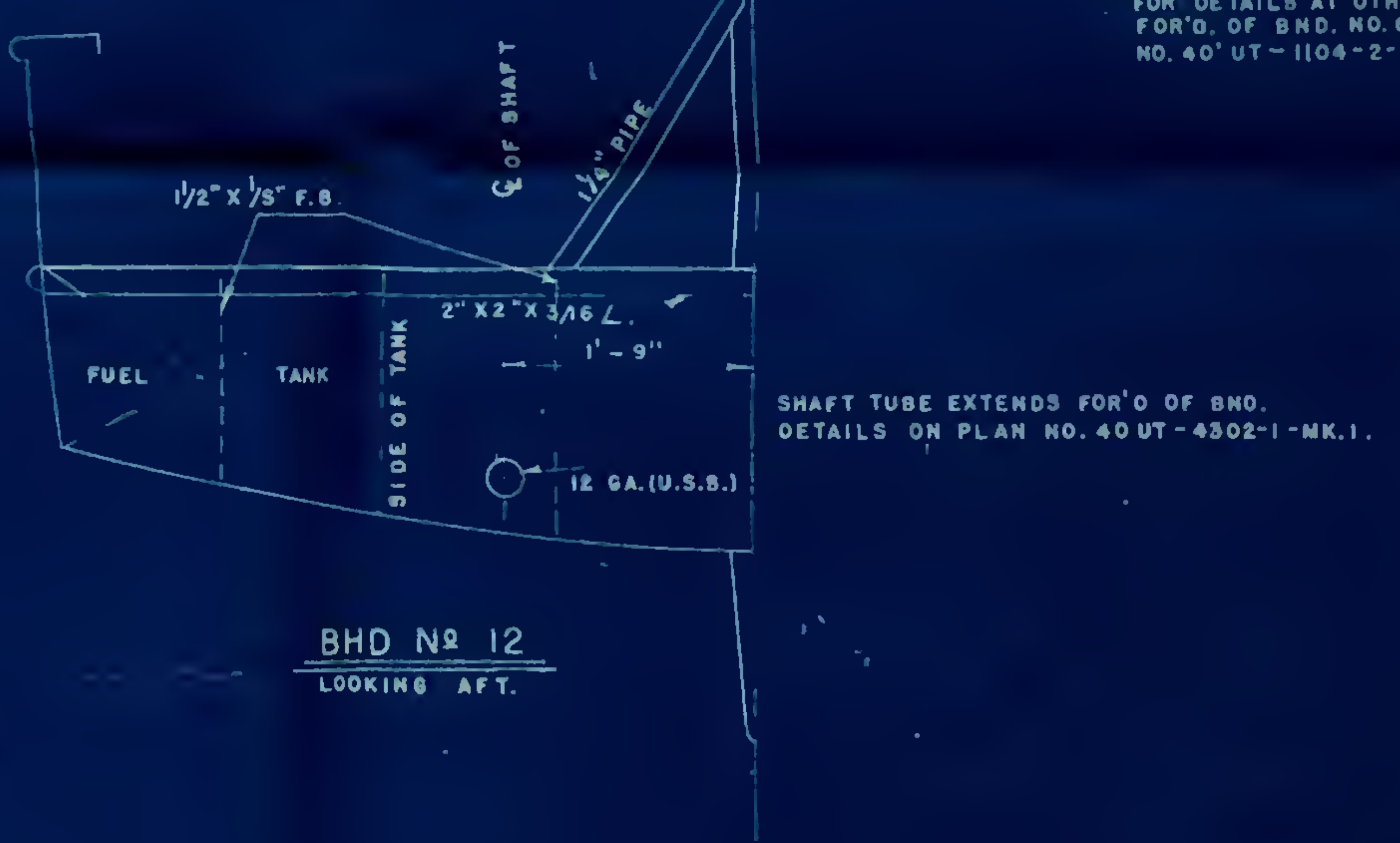
DETAIL - DK. HOUSE EDGE

FULL SIZE



DETAIL OF STIFFENER

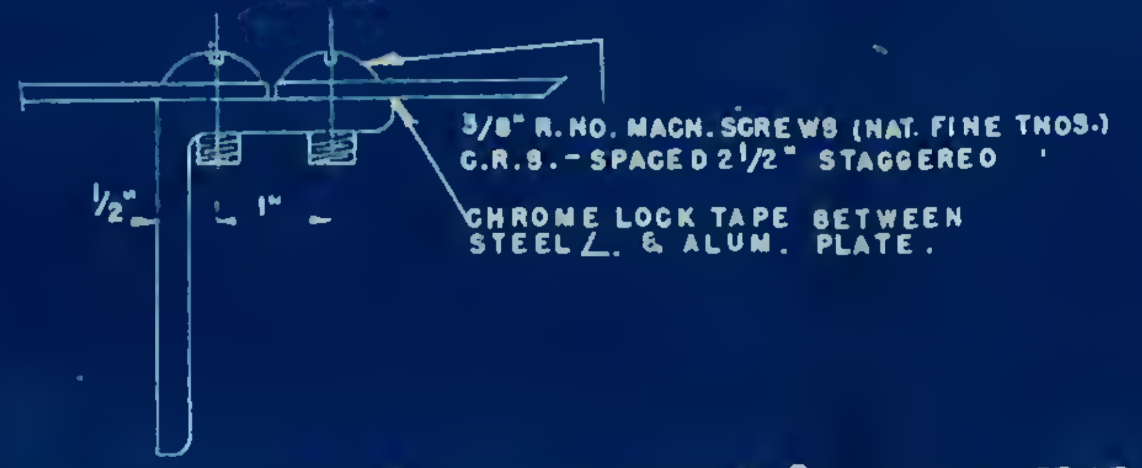
FULL SIZE



BHD Nº 12

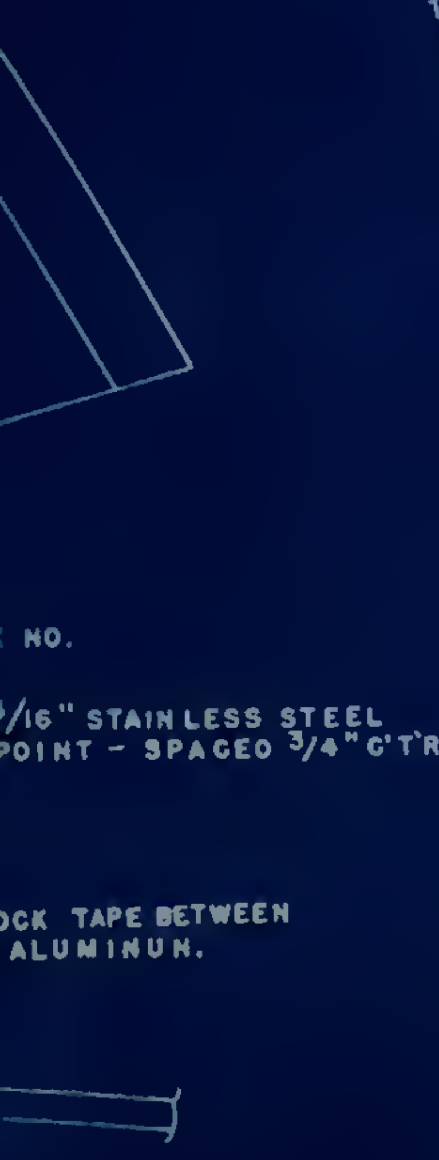
LOOKING AFT.

SHAFT TUBE EXTENDS FOR'D OF BHD. DETAILS ON PLAN NO. 40 UT - 4302-1-MK.1.

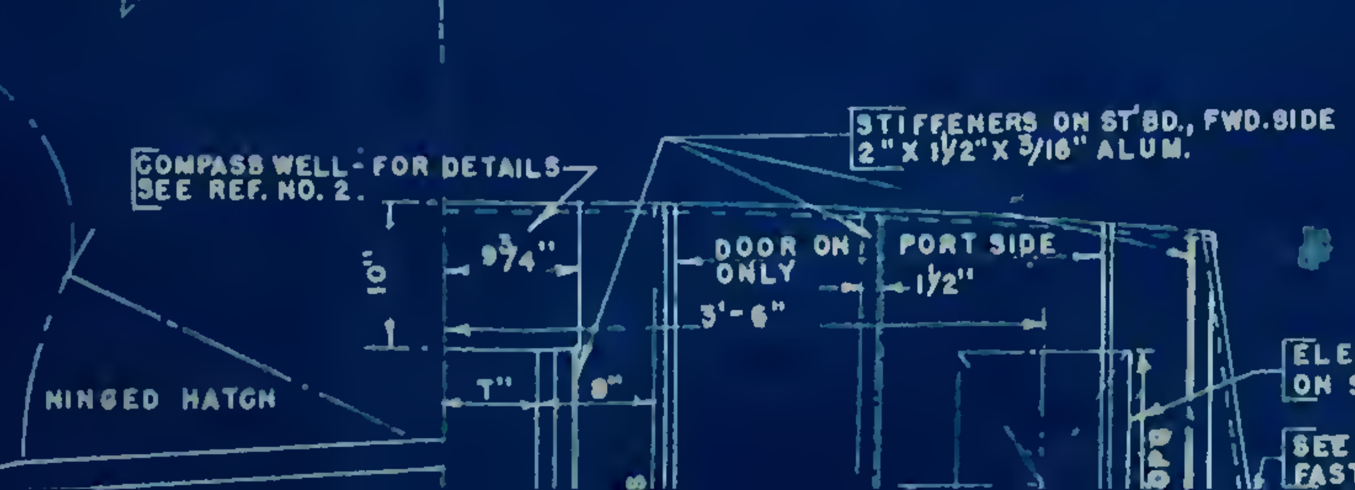

3/8" R. HD. MACH. SCREWS (NAT. FINE THDS.) C.R.S. - SPACED 2 1/2" STAGGERED
CHROME LOCK TAPE BETWEEN STEEL L. & ALUM. PLATE.
1/2"
1"

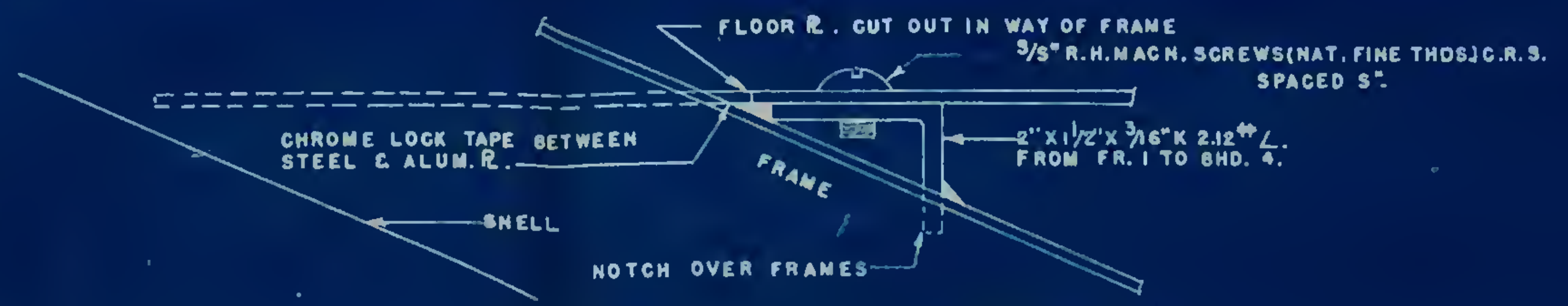
DETAIL - FLOOR PL. FASTENING ON ℄ AFT OF FR. 15

HALF SIZE


NO.
/16" STAINLESS STEEL POINT - SPACED 3/4" C'T'RS.
CK TAPE BETWEEN ALUMINUN.

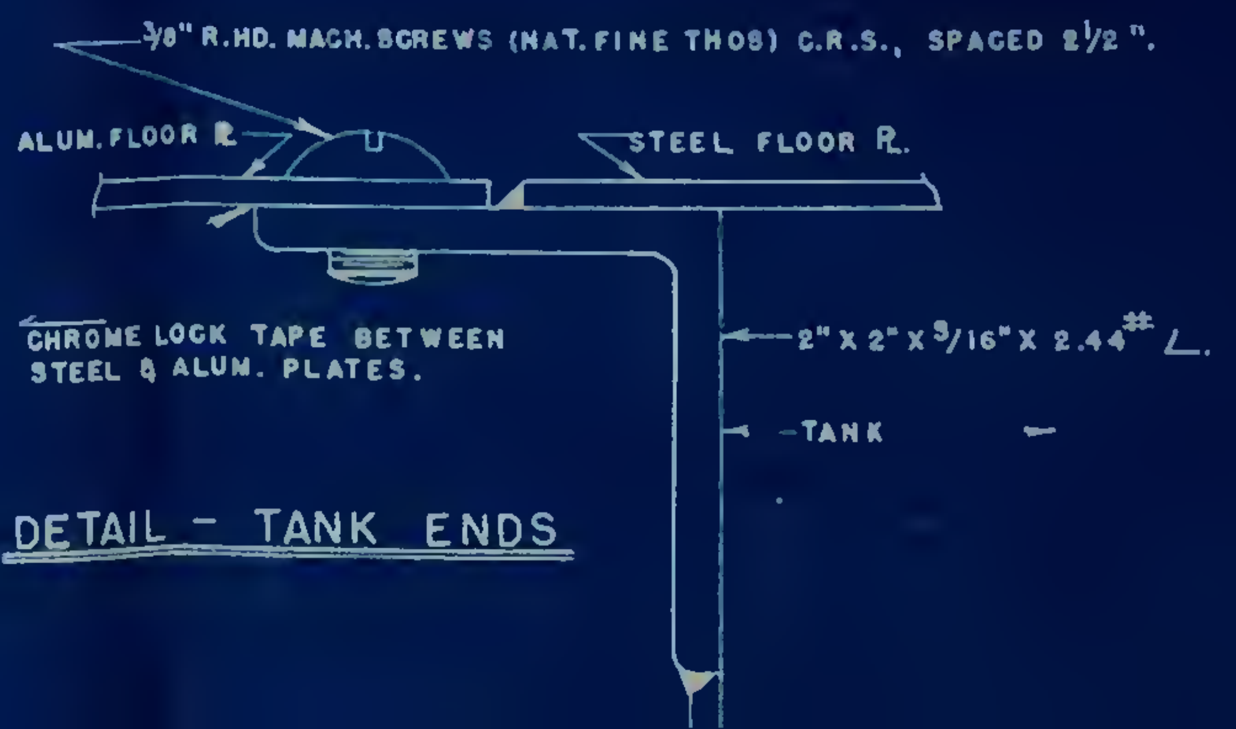
CK HOUSE FASTENING


COMPASS WELL - FOR DETAILS SEE REF. NO. 2.
STIFFENERS ON ST'BD., FWD. SIDE 2" X 1 1/2" X 3/16" ALUM.
10"
9 3/4"
DOOR ON PORT SIDE ONLY
1/2"
3'- 6"
7"
8"
HINGED HATCH
ELECTRIC PANEL OPENING ON ST'BD. SIDE ONLY
SEE DETAILS DECK HOUSE FASTENING.


FLOOR PL. CUT OUT IN WAY OF FRAME
3/8" R.H. MACH. SCREWS (NAT. FINE THDS) C.R.S. SPACED 8".
CHROME LOCK TAPE BETWEEN STEEL & ALUM. PL.
2" X 1 1/2" X 3/16" X 2.12# L. FROM FR. 1 TO BHD. 4.
FRAME
SHELL
NOTCH OVER FRAMES

FASTENING DETAIL - CABIN FLOOR PL.

HALF SIZE


3/8" R.HD. MACH. SCREWS (NAT. FINE THDS) C.R.S., SPACED 2 1/2".
ALUM. FLOOR PL.
STEEL FLOOR PL.
CHROME LOCK TAPE BETWEEN STEEL & ALUM. PLATES.
2" X 2" X 3/16" X 2.44# L.
TANK

DETAIL - TANK ENDS

OUTBOARD EDGE. RIVETED WITH 3/16" STAINLESS STEEL RIVETS.
TRANSOM SEAT
3/4" PIPE (FR. 2 & 3)
SEE FASTENING DETAIL
3/16" STAINLESS STEEL POINT - SPACED 3/4" C'T'RS.
LOCK TAPE BETWEEN ALUMINUM.
FRAME Nº 3
3/4" STD. PIPE
12 GA. (U.S.S.) STEEL
EXP. METAL
1" x 1" x 1/8" L.
36" W.L.
BULKHEAD Nº 0
.091" ALUM. PLATE & S.S., 11 GA.
DETAIL - DK. HOUSE EDGE
FULL SIZE
DETAIL OF STIFFENER
FULL SIZE
BHD Nº 12
LOOKING AFT.
3/8" R.HD. MACH. SCREWS (NAT. FINE THDS.) C.R.S. - SPACED 2 1/2" STAGGERED
CHROME LOCK TAPE BETWEEN STEEL ∠ & ALUM. PLATE.
DETAIL - FLOOR ℞. FASTENING ON ℄ AFT OF FR.15
HALF SIZE
FLOOR ℞. CUT OUT IN WAY OF FRAME
3/8" R.H. MACH. SCREWS (NAT. FINE THDS.) C.R.S. SPACED 6"
CHROME LOCK TAPE BETWEEN STEEL & ALUM. ℞.
FRAME
SHELL
2" x 1 1/2" x 3/16" x 2.12# ∠. FROM FR. 1 TO 8NO. 4.
NOTCH OVER FRAMES
FASTENING DETAIL - CABIN FLOOR ℞
HALF SIZE
3/8" R.HD. MACH. SCREWS (NAT. FINE THDS) C.R.S., SPACED 2 1/2".
ALUM. FLOOR ℞
STEEL FLOOR ℞
CHROME LOCK TAPE BETWEEN STEEL & ALUM. PLATES.
2" x 2" x 3/16" x 2.44# ∠
TANK
DETAIL - TANK ENDS
COMPASS WELL - FOR DETAILS SEE REF. NO. 2.
STIFFENERS ON ST'BD., FWD. SIDE 2" x 1/2" x 3/16" ALUM.
DOOR ON PORT SIDE ONLY
HINGED HATCH
ELECTRIC PANEL OPENING ON ST'BD. SIDE ONLY
SEE DETAILS DECK HOUSE FASTENING.
TOE RAIL
SEE RIVETING DETAIL
SEE DETAIL SPRAY SHIELD
GUN LOCKER
ENCL. FOR MORSE CONTROLS
3/4" DIA. EXTRUDED SHAPE - DIE NO. 4477.
11 GA. S.S. & ALUM.
4' TO BASE LINE
BULKHEAD TO BE WATERTIGHT UP TO 4' ABOVE BASE LINE
36" W.L.
2'-8" W.L.
CK HOUSE FASTENING
LL SIZE
1/2 FLG.
3/4" PIPE AT FR. 9
AT FRS. 6 & 10.
2 5/8" x 3" x 3/16" L
3/4" PIPE
1/4 PIPE
FRAME Nº 10
LOOKING AFT
BHD. Nº 4
LOOKING AFT.
3/8" R.HD. MACH. SCREWS (NAT. FINE THDS.)
FLOOR ℞
2" x 2" x 3/16" x 2.44# ∠.
CHROME LOCK TAPE BETWEEN STEEL ∠ & ALUM. ℞.
DETAIL - FLOOR ℞. FASTENING
AT FRS. 1, 2 1/2", 7 1/2 & BET. 11 & 12
HALF SIZE
KNUCKLE OR WELD
11 GA. (U.S.S.)
LIMBER HOLE
3/16 ℞.
NORMAL TO HULL
DETAIL - SPRAY SHIELD
HALF SIZE
SUPERSEDES PLAN NO. 40UT-0103-5-MK I.
CAMBER 1/2" PER FT.
3/8" ℞. FLANGED 1 1/2"
EMER. TILLER BRK'T. SEE REF. # 15.
℄ SHAFT
11 GA. (U.S.S.) STEEL
3/4" PIPE
2 1/2" x 2 1/2 x 3/16" ∠.
FRAME Nº 15.
TRANSOM
EXPANDED
STIFFENERS CUT FROM 6" J.I. BEAMS.
PLUG WELDS - 1/4" HOLES AT 2" CTRS.
12 GA.
3/4" ϕ ROD
TYPICAL SKEG DETAIL
11 GA (U.S.S.)
CHINE DETAIL - AFT OF FR.10
HALF SIZE

REFERENCE PLANS

REF. NO.	TITLE	C.G. HQS. DR. NO.	C.G. YARD DR. NO.
1	ARR'GT. & DETAILS OF TRANSOM SEAT IN FWD. COMP.	40 UT - 3306 - 1.	40 UT - 5506 - C.G.Y - 1.
2	ARR'GT. & DETAILS OF MORSE CONTROL ENCL. & GUN LOCKER.	40 UT - 1107 - 2.	40 UT - 1107 - C.G.Y. - 1.
3	ARR'GT. & DETAILS OF ANCHOR STOWAGE	40 UT - 2605 - 2.	40 UT - 2605 - C.G.Y. - 2.
4	LOCATION OF 15# CO^2 BOTTLE	40 UT - 9300 - 1.	40 UT - 9300 - C.G.Y. - 1.
5	DET. OF INSPECTION PLATES IN PILOT H'SE & LITTER COMP'T.	40 UT - 1106 - 2.	40 UT - 1108 - C.G.Y. - 2.
6	ARR'GT. & DETAIL CONTROL BOX FOR OUTSIDE STEERING.	40 UT - 2200 - 7.	40 UT - 2200 - C.G.Y. - 6.
7	FUEL OIL TANKS & COCKPIT DK. AFT. OF FR. NO. 12.	40 UT - 5501 - 7.	40 UT - 5501 - C.G.Y. - 2.
8	DETAILS - CLEANOUT IN TOP OF FUEL OIL TANKS.	40 UT - 5501 - 8.	40 UT - 5501 - C.G.Y. - 1.
9	LIFTING SLING	40 UT - 8201 - 1 MK. I-C	—
10	ARR'GT. & DETAILS OF PIPE SUPPORT AT FR. 5.	40 UT - 4826 - 6.	40 UT - 1106 - C.G.Y. - 4.
11	FOUNDATION FOR MOTOROLA TRANSMITTER	40 UT - 8701 - 3.	40 UT - 8701 - C.G.Y. - 3.
12	FOUNDATION FOR AN/URO-7 CONVERTER	40 UT - 8701 - 4.	40 UT - 8701 - C.G.Y. - 4.
13	ARR'GT. & DETAILS OF MIS'C'L STOWAGE BRACKETS	40 UT - 3000 - 1.	40 UT - 3000 - C.G.Y. - 1.
14	ARR'GT. & DETAILS OF CABIN DOOR IN BHD. 6.	40 UT - 1602 - 4.	40 UT - 1603 - C.G.Y. - 1.

REVISION	DATE	APPD.		BY
B	11-12-58		CHANGED BOTTOM ℞ THK. TO 7.65# BETWEEN 3" FWD. OF FR. 12 AND STERN.	9.24.B.
A	11-1-51	HHR	ADDED LIST OF REFERENCE PLANS AND MODIFIED DRAWING TO AGREE WITH SAME.	J.R.B.

U. S. COAST GUARD HEADQUARTERS WASHINGTON 25 D.C.

NAVAL ENGINEERING

DESIGNED -
DRAWN - FHK
TRACED -
CHECKED -

40' STEEL UTILITY BOAT

CONSTRUCTION PLAN

CHIEF OF SECTION

APPROVED G. F. Schumacher CDR 11/55.
U.S.C.G. CHIEF OF DIVISION
DATE 5/11/51

C. G. DRAWING NO.
40UT-0103-10 MK. I. MOD. I.

SCALE AS SHOWN SHEET ___ OF ___

CG-3409 A 12 52

13.5 SQ. FT.

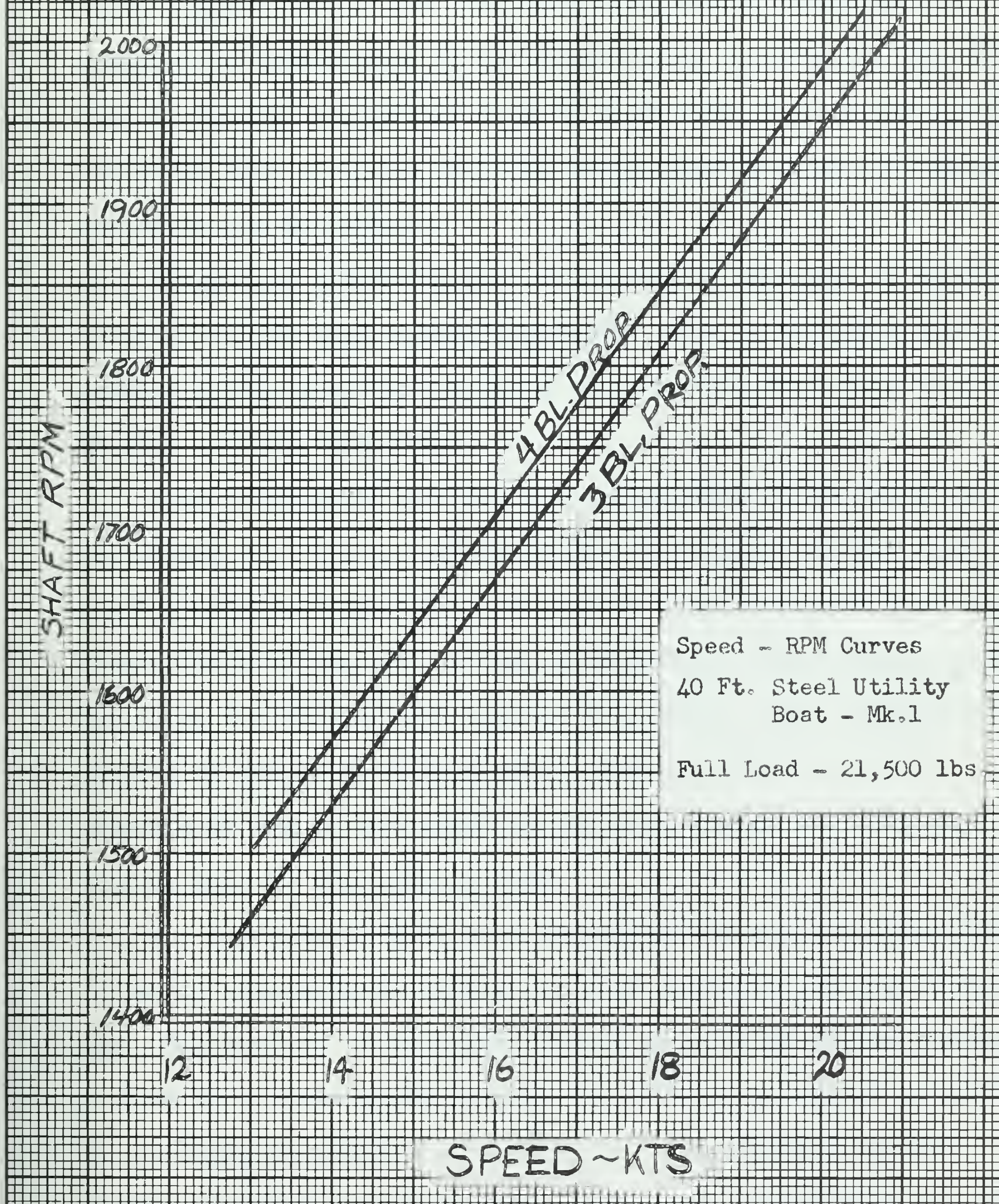

2000
1900
1800
1700
1600
1500
1400
SHAFT RPM
12
14
16
18
20
SPEED ~KTS
4 BL. PROP.
3 BL. PROP.
Speed - RPM Curves
40 Ft. Steel Utility
Boat - Mk. 1
Full Load - 21,500 lbs

FIGURE 3

I.- INTRODUCTION

1. The medium "semi-planing" hull is coming into wide use in both commercial and government service. The particular design used in the tests reported here is the Forty Foot Steel Utility Boat, Mark 1, designed and manufactured by the United States Coast Guard. In addition to the over two hundred boats in Coast Guard service throughout the world, many have been built for use by other governmental agencies and by foreign governments.

Though each individual unit of a design of this type is relatively inexpensive, the large number constructed seems to justify a field test program to alleviate the paucity of reliable data concerning the behavior of such craft in rough water.

Some experimental work has been accomplished in the United States and abroad, (4), (3), (10)* concerning the response of high speed planing hulls to rough water. In general these boats have been full planing hulls of the "PT" or high speed aircraft rescue launch type. The Forty Foot Utility Boat operates in a "shadow zone" between fully planing and displacement type hulls. Buoyant effects are still significant even at full power and the boat behaves in a different fashion than the pure planing hull.

The test program to be proposed attempts to determine the dynamic "slamming" pressures in critical areas of the bottom plating of the hull, the vertical accelerations present in slamming and the stresses induced in selected bottom panels. In addition, an attempt is made to ascertain the response of plating near the propellers to the dynamic pressures developed during smooth water operation of the boat.

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* - ( ) indicates literature citations as noted in the bibliography

It is hoped that a careful analysis of the observed phenomena will provide additional information to the maritime industry concerning the behavior of a type of boat which is becoming increasingly important in both naval and commercial applications.

2. Failures of the 40 Foot Utility Boat in Service

In 1957 Coast Guard Headquarters requested a listing of hull failures in the forty foot boat from each Coast Guard District. The thesis group obtained these reports and attempted to pinpoint structural trouble spots in the boat. In general two areas of trouble have been noted. The bottom aft, near the propellers, has been plagued with small cracks and the bottom area forward near station 3 has failed occasionally under severe service. Several detail locations have caused trouble in the past. These include struts and fuel tank bulkheads. These failures were due to design details and have been corrected by alterations.

It was impossible to pinpoint the exact location of cracks in most of the failure reports submitted. However, trends indicate that the plating over the propellers has been the critical area in the boat. Measured plating strains in this area, however, are quite low.

3. Operating Conditions

The forty foot utility boat is of semi-planing type. At maximum speed only a portion of the boat's displacement is supported by dynamic pressures. In order to obtain a more realistic picture of the actual operating condition of the boat, it was necessary to separate the dynamic and buoyant effects.

During the test series a record of planing angles was kept for various speeds.

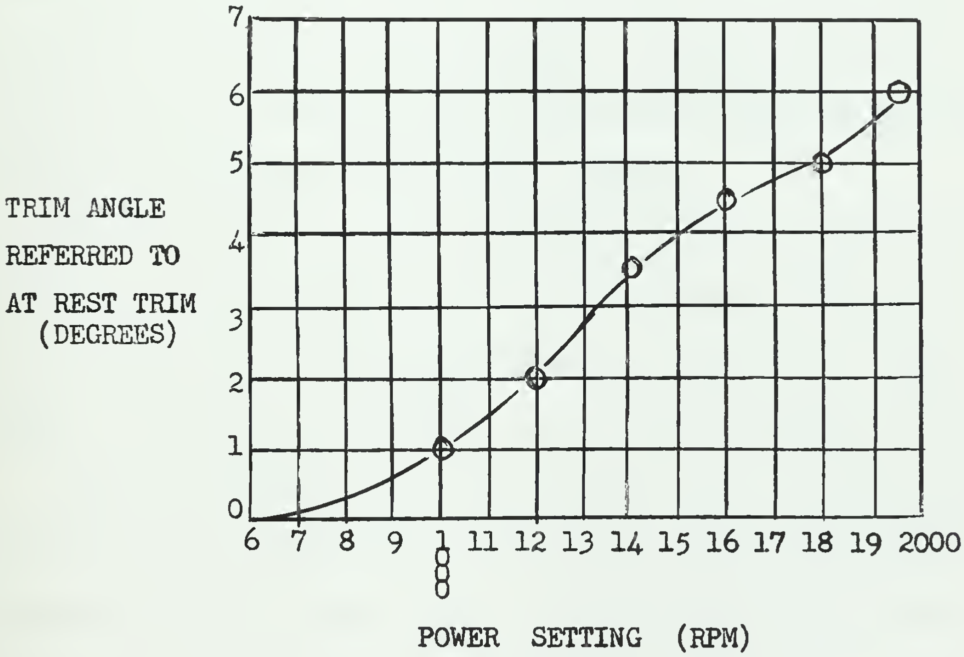


FIG. 4

The planing angle never levels off as speed increases to the maximum available power point.

At maximum power (1950 RPM, 19.5 knots) the planing angle is approximately 6 degrees.

The boat's entry point at speed was determined from photographs taken from another boat. Knowing the entry point and the trim angle it was possible to establish a mean planing waterline.

During the tests the wave pattern at the side of the boat was observed as was the planing draft at several points. From this information a modification to the mean planing waterline was made (fig. 2). After establishing the immersed portion of the boat the integrated volume was found as was the center of buoyancy at maximum speed.

The calculated displaced volume was 9502 lbs. with the center of buoyancy 12.18 ft. forward of the transom. The calculated dynamic force was determined from this and from the measured displacement of the boat (21,518 lbs.) as 12,016 lbs. with the center of planing pressure 22.87 ft. forward of the transom. The boat in its service full load condition at maximum speed is thus supported by approximately 56% planing pressure and 44% by buoyant effects.

The theoretical pressure distribution for an equivalent flat plate was calculated (29). This gave a center of pressure 22.53 ft. forward of the transom and a theoretical planing force of 17,032 lbs. The center of pressure agrees rather closely with the observed conditions.

By superimposing the plot of buoyant forces at maximum speed with the theoretical pure planing pressure distribution, corrected to give the required total dynamic force, an approximate pressure distribution over the bottom at maximum speed was obtained (fig. 5). Though the quantitative information on which this plot is based is subject to many assumptions, it is felt that the general picture obtained is entirely reasonable.

At a nominal planing angle of six degrees from the at rest position the bottom area in the vicinity of station 3 (the area in which the dynamic pressure is by far the highest) has approximately this angle.

Because of the pronounced "tuck" of the bottom aft this angle is almost zero in the area from amidships aft. Thus the lift generated here is less in proportion than if it also had a steeper planing angle. This has the effect of moving the center of pressure slightly forward. No account of this was taken in obtaining this rough pressure picture. For our purposes the keel line has been assumed as essentially parallel to the baseline.

The boat was designed for utility service. Considering the Skene powering coefficient* (28) as an adequate index of performance, this boat scores 182 compared to 205 for the 40 ft. MK 1 Navy rescue boat (3) and 214 for the proposed Offshore 44 ft. Boat discussed by Prof. Alan Murray (18).

This is not surprising considering that the 40 ft. Utility Boat was originally designed for a gross weight of 17,760 lbs. The higher service gross weight, of course, has a detrimental effect on planing performance.

* $$C = 1.15\,V_K\sqrt{\frac{\text{GROSS WEIGHT (lbs.)}}{\text{INSTALLED POWER (H.P.)}}}$$

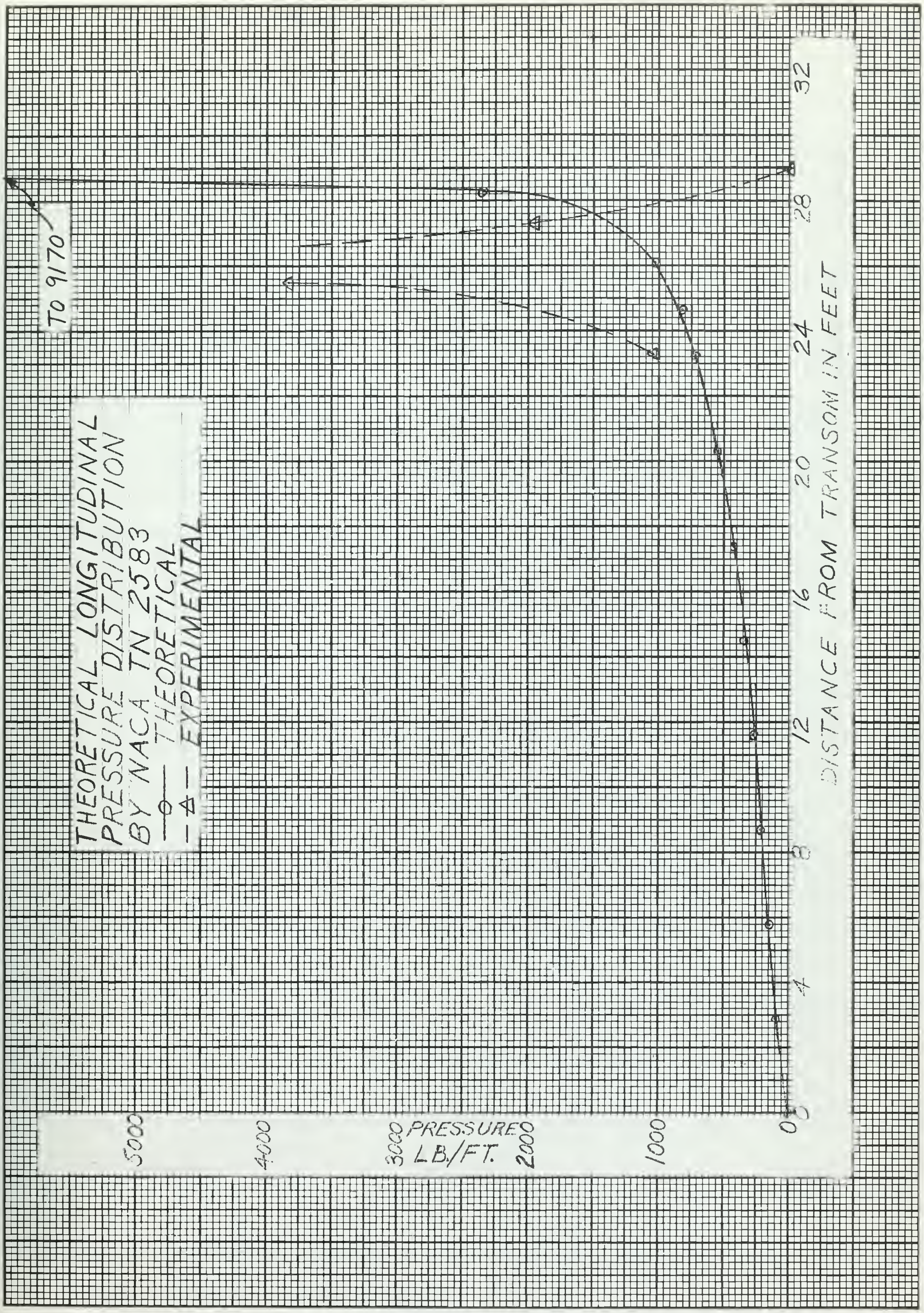

THEORETICAL LONGITUDINAL
PRESSURE DISTRIBUTION
BY NACA TN 2583
—o— THEORETICAL
-△- EXPERIMENTAL
To 9170
PRESSURES
LB./FT.
0
1000
2000
3000
4000
5000
0
4
8
12
16
20
24
28
32
DISTANCE FROM TRANSOM IN FEET

FIGURE 5

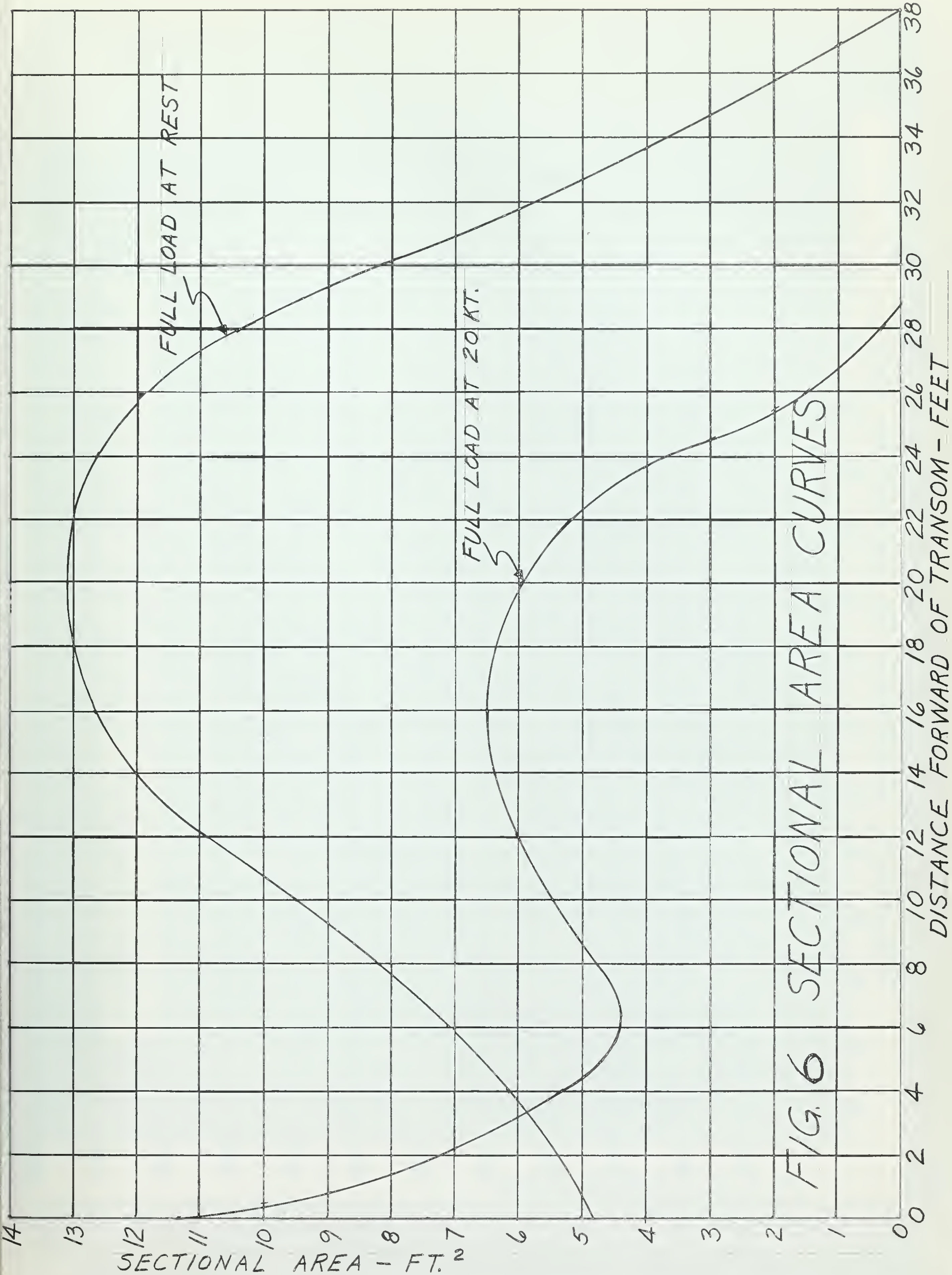


FIG. 6 SECTIONAL AREA CURVES
FULL LOAD AT REST
FULL LOAD AT 20 KT.
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
DISTANCE FORWARD OF TRANSOM - FEET
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
SECTIONAL AREA - FT.^{2}

FIGURE 6

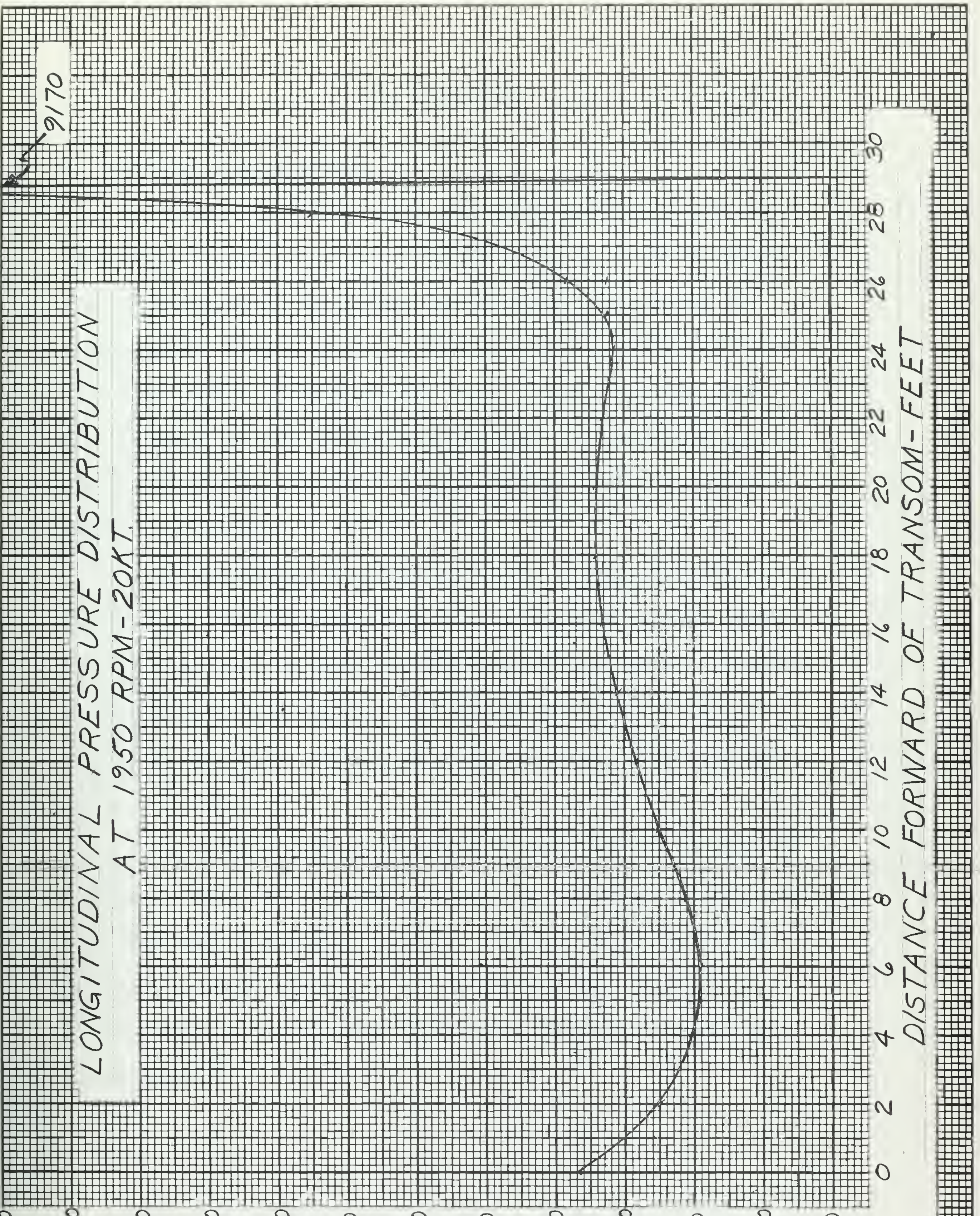

LONGITUDINAL PRESSURE DISTRIBUTION
AT 1950 RPM - 20 KT.
9170
DISTANCE FORWARD OF TRANSOM - FEET
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
PRESSURE - LB./FT.
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0

FIGURE 7

II. -PROCEDURE

1. Original Plan of Attack

In order to make full scale structural tests on a boat of this size, it was considered to be mandatory to do the installation of instruments and to take the necessary data during the summer months in good weather. It would have been impossible to have done further testing in this type of boat after the final date on which we took strain data, November 22, primarily because of the limitations on personnel operating the boat under adverse weather conditions.

It was originally intended to install pressure transducers, strain gages, and accelerometers at the same time so that simultaneous data could be taken in each bottom panel tested. Accelerometers were to be installed near the bow and at the center of gravity of the boat. This would allow the determination of both heave and pitch.

In the forward part of this type of boat, in the vicinity of station 3, there had occurred fractures in the bottom plating which indicated that slamming had probably resulted in pressures high enough to produce stresses in the bottom plating exceeding the fatigue limit of the material or even the ultimate strength of the material.

In order to determine whether these fractures were actually caused by fatigue or by exceeding the ultimate strength of the material, it was proposed to install strain gages in the panel in which maximum slamming pressure occurs. Gages were to be installed at the mid-length of panel edges, and a rectangular strain rosette was to be installed at the panel center to determine the direction and magnitude of principal stresses at this point.

The point of maximum pressure for the maximum impact condition was estimated to be 40% of the length from the bow, from the work of N. H. Jasper as given in DTMB Report C-175 (declassified). This enabled us to estimate the transverse and longitudinal position of the point of maximum pressure for the slamming condition. Pressure transducers were to be installed at the center of the panel closest to the estimated point of maximum pressure, and at the centers of the adjacent panels forward, aft, inboard, and outboard. This would give a coverage of 48 inches longitudinally, and 32 inches transversely in order to determine the location of the point of maximum pressure experimentally.

After it was determined which panel actually contained the point of maximum pressure, and therefore which panel had the highest loading as a whole, it was planned to install the strain gages in this panel and take simultaneous readings of pressure, strain, and acceleration. This would allow us to determine the relation between acceleration and pressure, and between pressure and stress. In this way we expected to verify or disprove the relation between acceleration and pressure as given by N. H. Jasper in DTMB Report C-175

(declassified). This report gives this relation for the motor torpedo boat YP-110, which is a 75 foot boat of 109,000 pounds displacement. It was expected that we might be able to determine the proportionality factor between maximum pressure and maximum acceleration for our type of boat so that in the future the bottom pressures could be predicted for boats of similar size and form, simply by knowing the speed of the boat and the acceptable acceleration which operating personnel could endure.

By measuring the dynamic pressures and the resulting strains during slamming it was expected that dynamic load factors could be established for boats of this size, form and type of construction which would be valid for the type of pressure variation curve recorded. These dynamic load factors were to be determined by comparison of measured stresses and stresses calculated from the measured pressure applied as if it were a static load. Dynamic load factors determined can be compared to those given by J. M. Frankland in DTMB Report 481.

In the area of the propeller field there have been a large number of bottom plating failures, both at the connection of the shaft struts to the bottom and at the edges of the panels. It was planned to investigate the pressures and stresses in these panels in order to determine whether these failures were produced by exceeding the fatigue limit as a result of pressure variations produced by the propellers, or whether they were produced by localized high stresses due to hard spots at the strut connections to the panels and the vibration transmitted

from the propeller shaft. Both 3 and 4 bladed propellers were to be used to determine the effects of each on the magnitude of stress developed in the bottom panels at various engine RPM. Calculations of the expected natural frequency of the bottom panels in the area of the propellers showed a natural frequency of about 138 cycles per second for simply supported edges and 254 cycles per second for fixed edges. It was therefore expected that there might be a large increase in the magnitude of stress in these panels near the maximum speed of the boat with 3 bladed and 4 bladed propellers. In service, these boats had been operated with only 3 bladed propellers and it was not previously determined whether any noticeable reduction of vibration would result from the use of 4 bladed propellers.

2. Actual Procedure

The point of maximum pressure at maximum slamming condition was estimated to be 26 feet forward of the transom. The center of the pressure transducer array was therefore located at the center of the panel at station 3, and the second panel outboard from the centerline. The other four transducers were located in the four adjacent panels. Test runs were made then to determine whether our calculated location of maximum planing pressure was in the panel showing the greatest recorded pressure. The center transducer of the array gave consistently higher pressure readings than the other four during slamming. It was therefore decided that the strain gages would be installed in this panel since the maximum stresses could be expected here.

In the area of the propeller field three panels were chosen in which to install pressure transducers. These were the panels closest to the propeller which had no structure attached such as struts or patches. These panels are shown in fig.12. No significant pressure differences were found between the three panels checked. This data was taken with 3 bladed propellers because these were the only ones available at that time.

Because of the prevailing good weather at that time, it was decided that it would be better to complete the data in the after panels first because they were in the open area exposed to the weather. The forward data could be done with poor weather because those panels are located in the cabin. There was no necessity for taking any forward and after data at the same time because they are produced by entirely separate causes, slamming and propeller field pressure variations, respectively.

Several attempts were made to install SR-4 paper strain gages in the after panel. However, each of these installations was either wet down by rain before the Duco cement had cured, or was rendered unreliable by the humid and salty atmosphere before the gages could be waterproofed. The result of every attempt at installation of strain gages was unreliable gages which varied seriously in their resistance readings.

At this time we had only a few days left in which to use the pressure transducers which had been borrowed from the David Taylor Model Basin. Since it appeared doubtful whether we would be able to get any successful strain gage installations in the weather then prevailing, it was decided to go ahead with only pressure and acceleration data. This would enable us to complete our survey of pressure and acceleration both forward and aft before we were required to send the transducers back to DTMB.

It was felt that if better weather conditions were obtained later that we might be able to continue with strain data and obtain the necessary correlation between strain and pressure data through accelerations.

Pressure data forward was taken at various speeds up to the maximum speed of the boat, about 1950 RPM (20 knots). All pressure data was taken with the 3 bladed propellers. This fact is of little interest however, because the maximum pressures forward are a result of only slamming and are independent of propeller action. Various speeds were used in order to determine at which speed slamming pressures became significant. In order to obtain waves of sufficient severity to produce hard slamming, it was necessary to employ a second boat to produce a high speed wake which we could cross over and thereby obtain one or two slams during each run. There was no weather of sufficient severity to produce the required waves at that time. It is believed that the slamming produced by crossing wakes was at least as severe and probably more severe, than any condition ever experienced

in actual service. Accelerations were measured near the bow and at the longitudinal position of the forward panel being tested. The acceleration at the center of gravity could not be measured because this would have required installation of the accelerometer in the engine compartment. The vibration in this area would preclude any accurate determination of accelerations. The acceleration of the center of gravity of the boat can be determined from the two accelerations measured.

The pressure data aft was taken in calm waters because the effects of slamming were found to have no appreciable effect on the pressures found in the after panels. In order to determine at exactly what speed the greatest vibration occurred in these panels, data was recorded at speeds from 1,000 to 1,950 RPM of the engines with both 3 and 4 bladed propellers.

After completion of the pressure data both forward and aft, further investigation was begun on means of installing strain gages in the bottom panels so that they would give reliable readings. It was at this time that the pressure sensitive cement, Eastman 910 was being introduced (see page 23). With the aid of this cement, which enabled the installation and use of the SR-4 paper gages within a matter of minutes, we were able to install the gages, make all necessary connections, and take data in one day with reliable and consistent results.

The pressure transducers had already been returned to DTMB by this time so that we were unable to make simultaneous readings of pressure and strain. The strain readings were therefore taken simultaneously with accelerations. The accelerations were taken at the same points as they had been taken during the pressure data runs. It was expected that the relation between strain and pressure would be established through common accelerations.

The strain data was taken on November 22, 1958. At that time the temperature was about 45°F. and there was 20 knots of wind, causing severe spray conditions at any speed over about 5 knots. In this temperature it would have been practically impossible to have installed strain gages with slow setting cement on the cold bottom panels. However, with the Eastman 910, it was possible to install, waterproof, and take data with the strain gages within a matter of minutes.

3. Instrumentation

The choice of instruments for this project was dictated almost entirely by availability. The instruments obtained were among the finest of their type but their inherent limitations, especially the limited number of recording channels, made data correlation difficult.

Pressure Pickups

Eight pressure pickups were obtained. These were DYNISCO P3C50 transducers manufactured by the Dynamic Instrument Company of Cambridge, Massachusetts.

TABLE I

DYNISCO P3C50 CHARACTERISTICS

Range:	0-50 lbs. (absolute)
Natural Frequency:	6000 cps.
Standard Resistance:	600 ohms.

The range of the available pickups was larger than that required. This resulted in a lower than optimum electrical output to the strain gage amplifiers.

Amplifying and Recording Equipment

The amplifying and recording equipment was the integrated Model 150 system developed by the Sanborn Company of Waltham, Massachusetts.

TABLE II

SANBORN MODEL 150 CHARACTERISTICS

The following apply to the complete system including:

Preamplifier, Power Amplifier and Galvanometer when used as an integrated system

Frequency: 0 - 100 cps. (90% response for 10 mm deflection at 100 cps.)

Rise Time: 5 milliseconds to full scale

Linearity: Essentially linear over the middle four centimeters of chart width

Sensitivity: 1.0 millivolt per centimeter as used

Drift: Less than 0.01 mm. per hour

A six channel Model 156-100-BWP recorder was available for use. Two different types of preamplifier were used during the course of the tests. Stabilized DC Amplifiers, Model 150-1800, were used for pressure and acceleration measurements while Model 150-1100 Carrier Preamplifiers were used for strain gage measurements.

The fact that the total number of channels available at any one time was only six was a distinct disadvantage during the tests. It would be advantageous to consider multichannel aircraft flight test gear for future work of this type because of its lighter weight for a greater number of recording channels.

Strain Gages and Associated Equipment

The strain gages used were standard Baldwin-Lima-Hamilton types A3 and AR1. No difficulty was found in using these gages once they were installed. However, it was found to be impossible

to install these gages under the damp conditions prevailing in the bilges of the boat. By the time the adhesive had dried, the gages picked up enough moisture to be useless. This difficulty persisted during the first portions of the test series. Since it was impractical to remove the boat from the water for strain gage installation an alternate method was used for mounting the gages. Professor W. M. Murray of Massachusetts Institute of Technology, suggested the use of Eastman 910 cement, then just coming on the market. This pressure sensitive cement dries in a matter of seconds and allows immediate waterproofing of the strain gage. The group experienced marked success in the use of this adhesive. It is superior for marine test work of this sort. The gages were waterproofed with several thin layers of melted paraffin. As a precautionary measure the completed installations were covered with petroleum jelly. The gages remained waterproof after two weeks under stagnant salt water.

Accelerometers

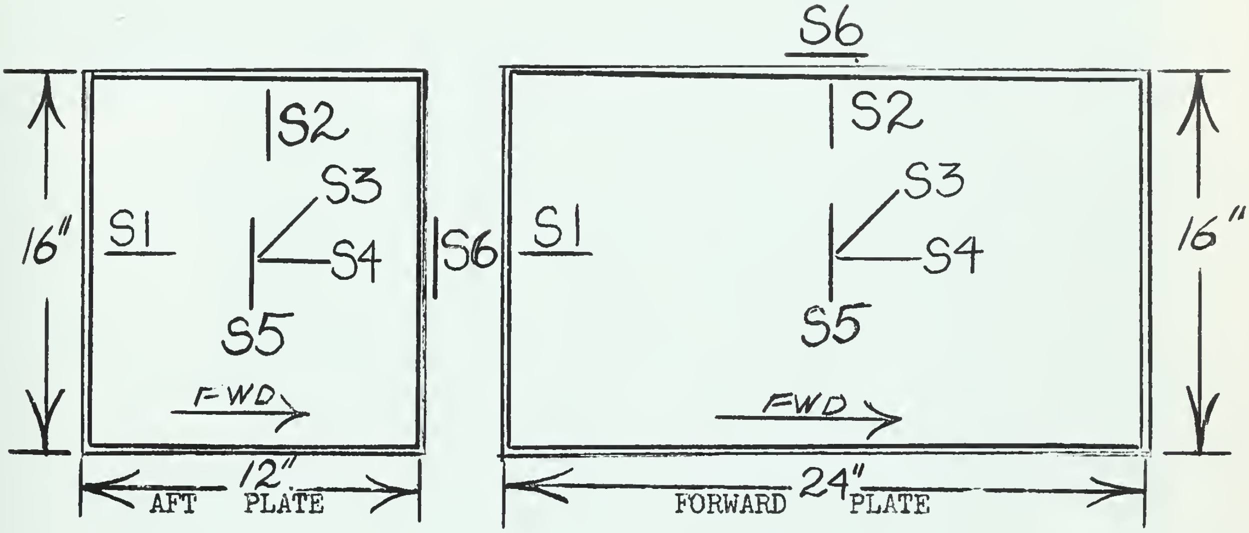
Heave accelerations were measured at frame 0 and frame 4-1/2 by the use of Statham Accelerometers. The characteristics of the accelerometers follow:

TABLE III

Location:	Frame 0	Frame 4-1/2
Model:	Statham A6a-1.5-350	Statham A5a-1.5-35
Serial:	3024	6429
Excitation Voltage:	6 volts	6 volts
Range:	± 1.5 g	± 1.5 g

Power Supply

Since the forty foot utility boat has a direct current electrical system, an auxiliary generator was procured to furnish 115 volt, 60 cycles, AC power. The generator used was an ONAN 2.5 KW portable. Trouble was experienced in shielding the cable run from the transducers to the amplifiers against stray AC from the generator. Careful attention must be paid to grounding the equipment, especially in a case such as this where the generator is, of necessity, close to cable runs.



NOT TO SCALE

FIGURE 8

STRAIN GAGE LOCATIONS ON PANELS
INSTRUMENTED FOR STRAIN MEASUREMENTS

Gages marked "S6" are mounted on the structural member adjacent to the plate.

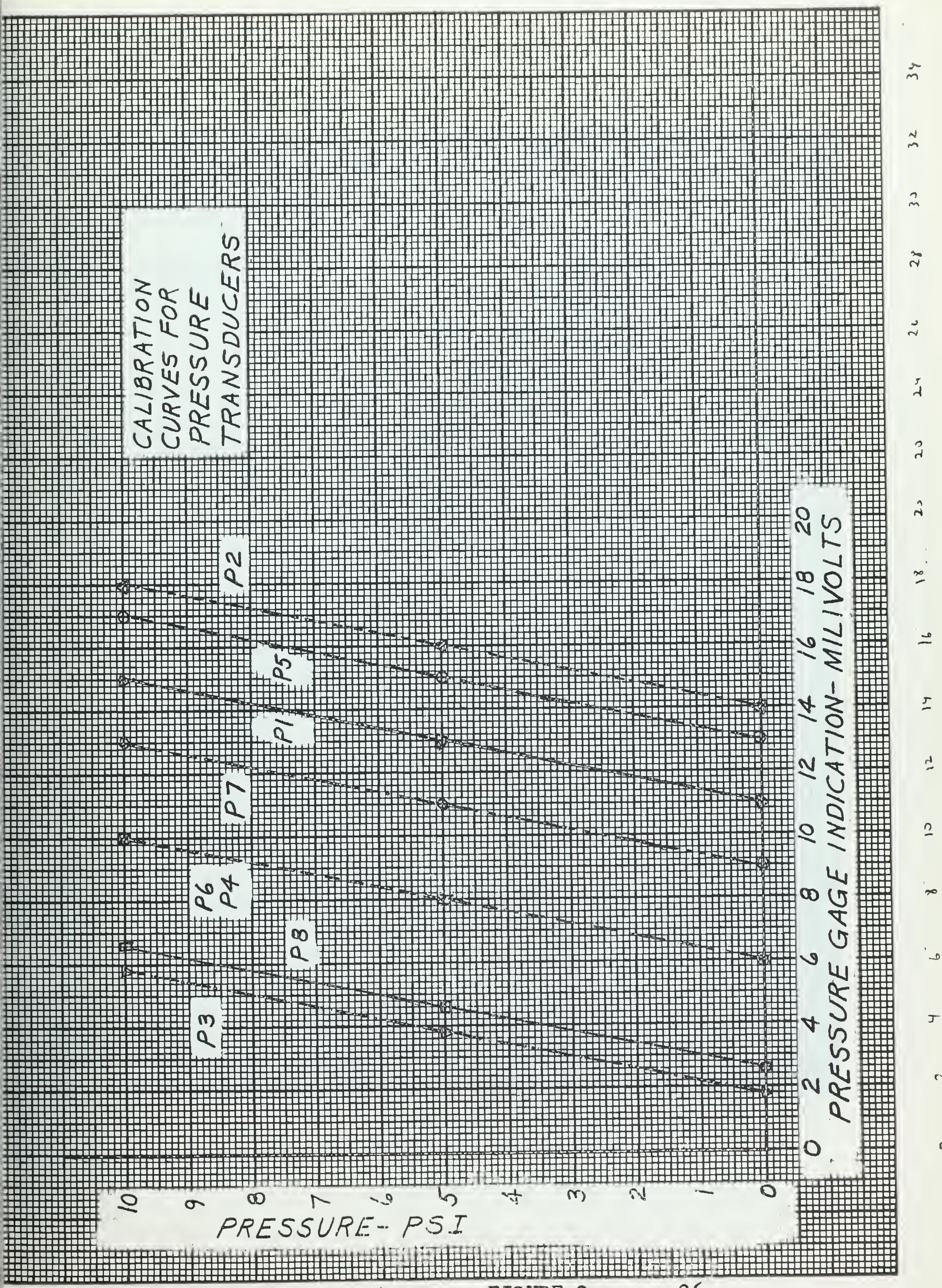

CALIBRATION CURVES FOR PRESSURE TRANSDUCERS
PRESSURE- PSI
0
1
2
3
4
5
6
7
8
9
10
PRESSURE GAGE INDICATION- MILIVOLTS
0
2
4
6
8
10
12
14
16
18
20
P1
P2
P3
P4
P5
P6
P7
P8

FIGURE 9

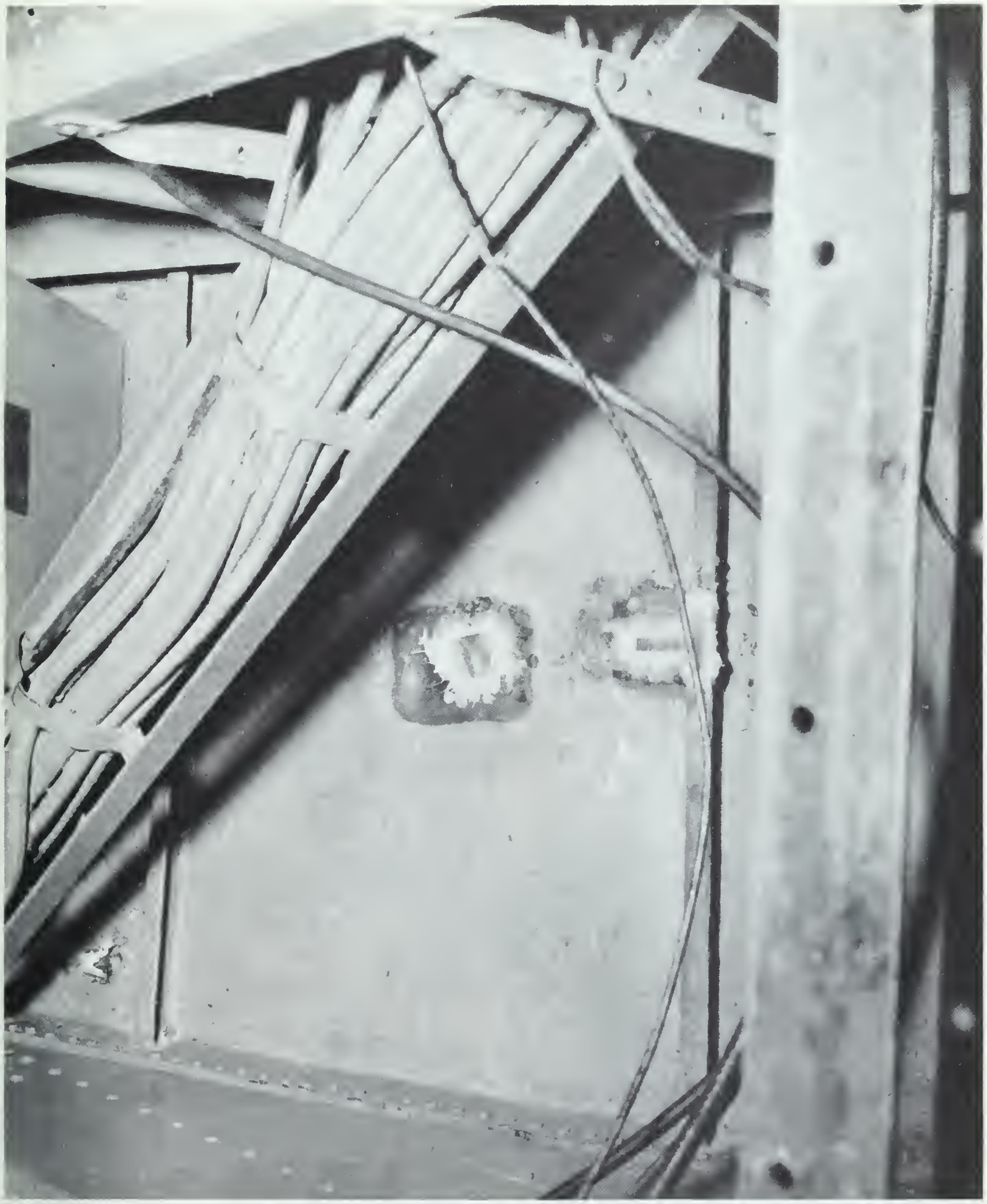


FIGURE 10
TYPICAL STRAIN GAGE INSTALLATION

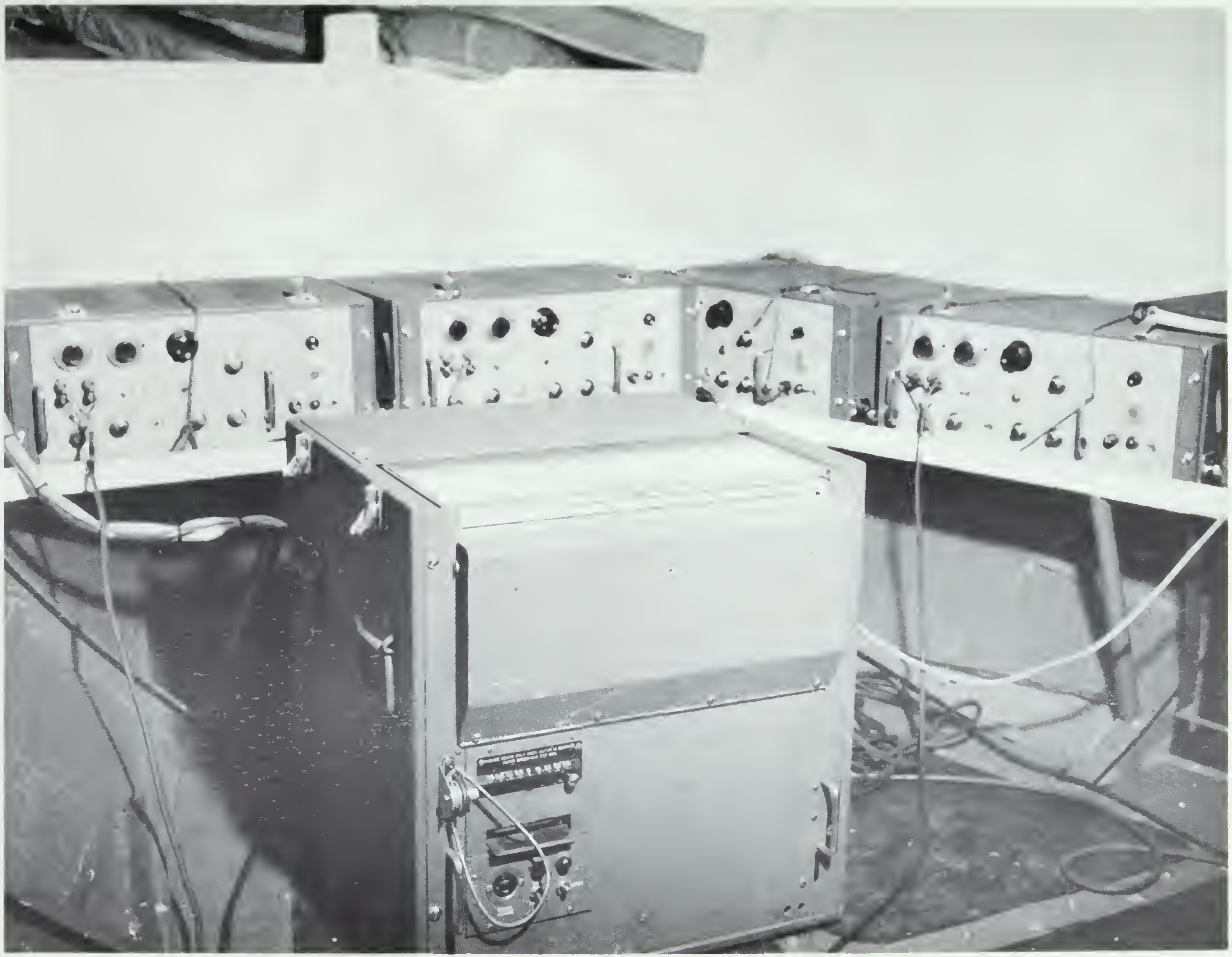


FIGURE 11
DATA RECORDING STATION

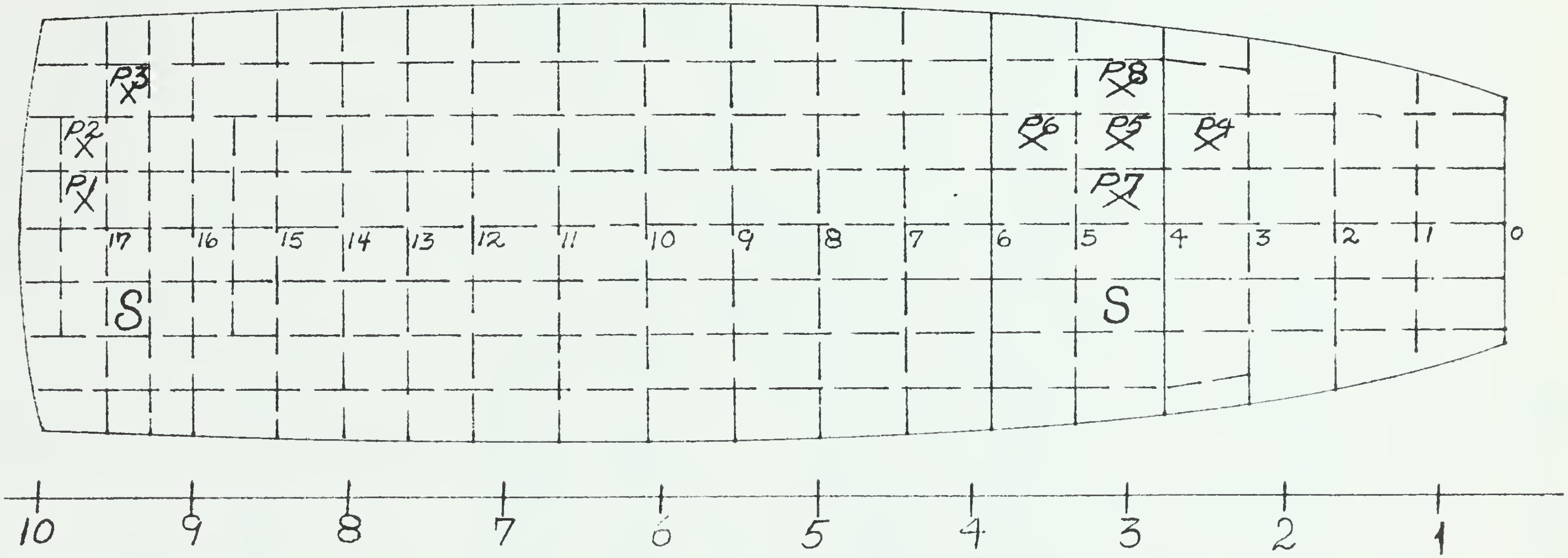
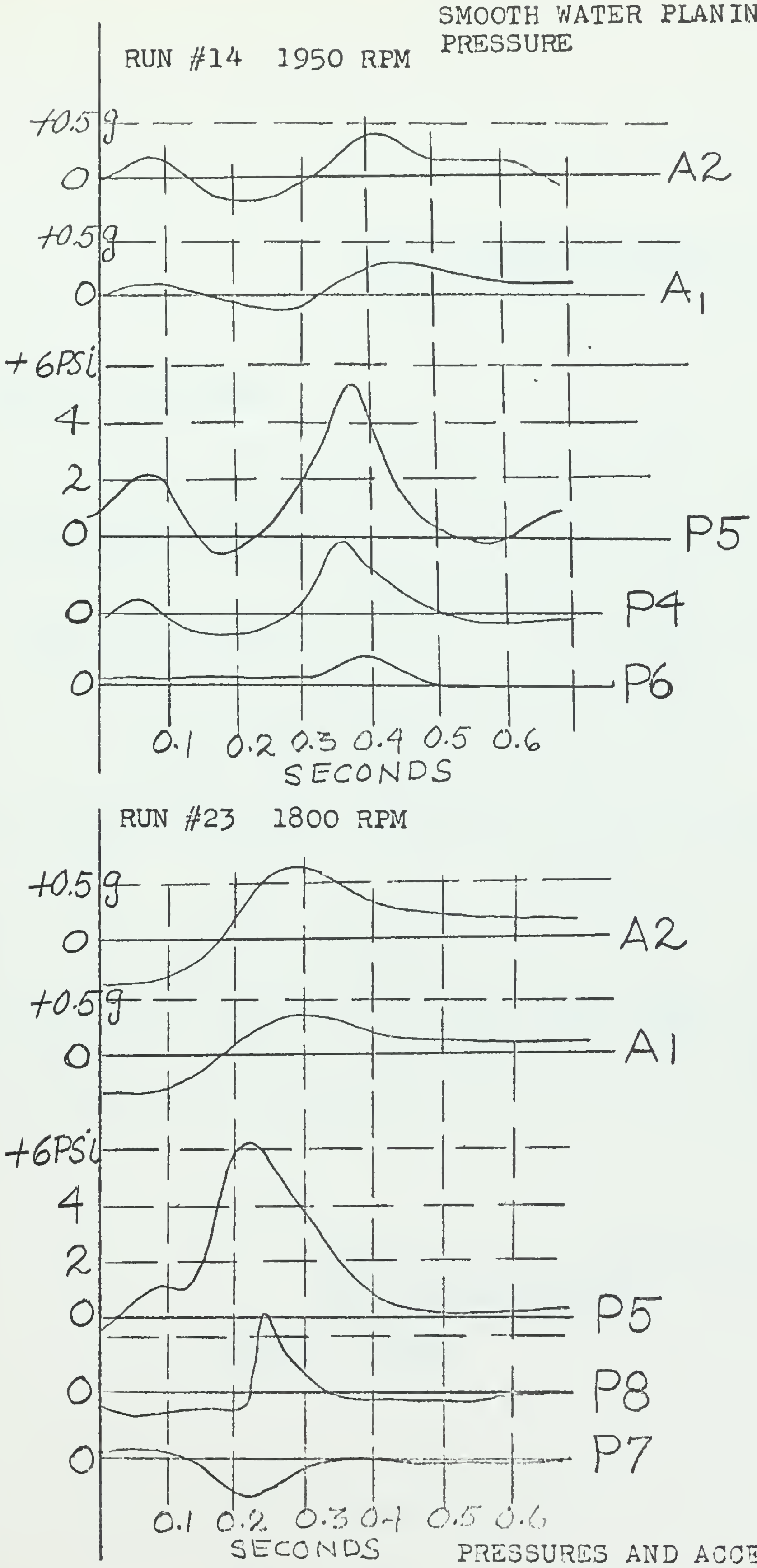


FIGURE 12

BOTTOM SHELL EXPANSION SHOWING INSTRUMENT LOCATIONS

P denotes pressure transducer
S denotes panel instrumented for strain

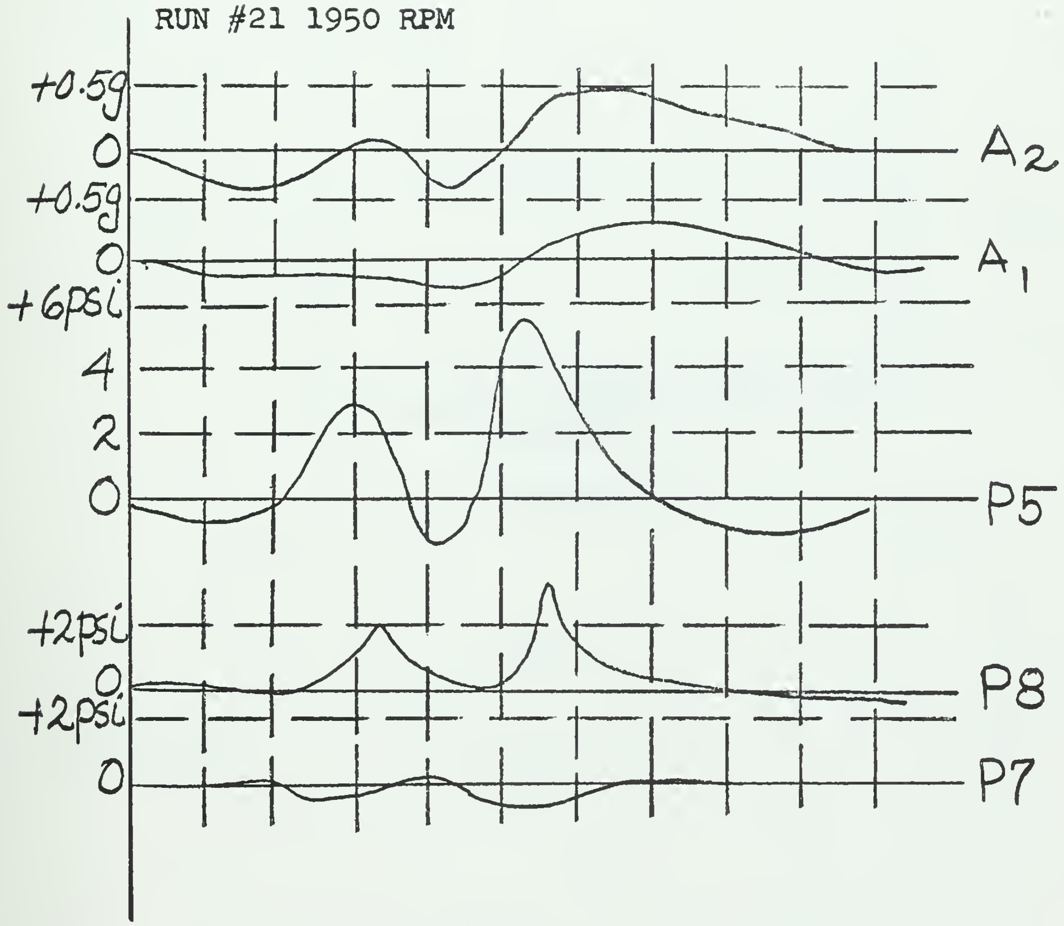
"ZERO" PRESSURE REFERS TO SMOOTH WATER PLANING PRESSURE



PRESSURES AND ACCELERATIONS FOR TYPICAL SLAMS

FIG. 13

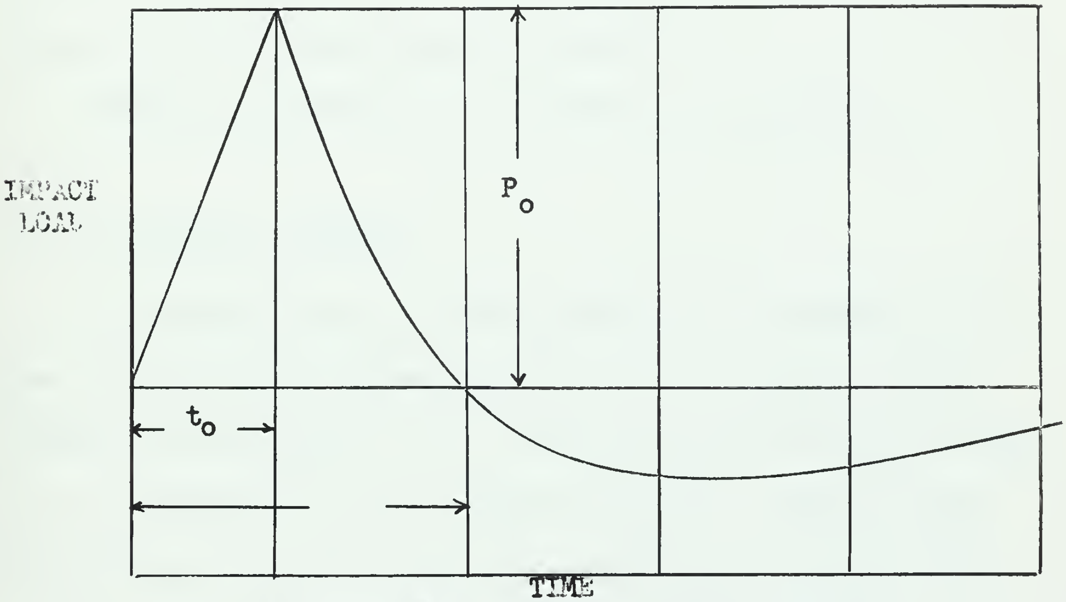
"ZERO" PRESSURE REFERS TO
SMOOTH WATER PLANING PRESSURE



PRESSURES AND ACCELERATIONS
FOR A TYPICAL SLAM

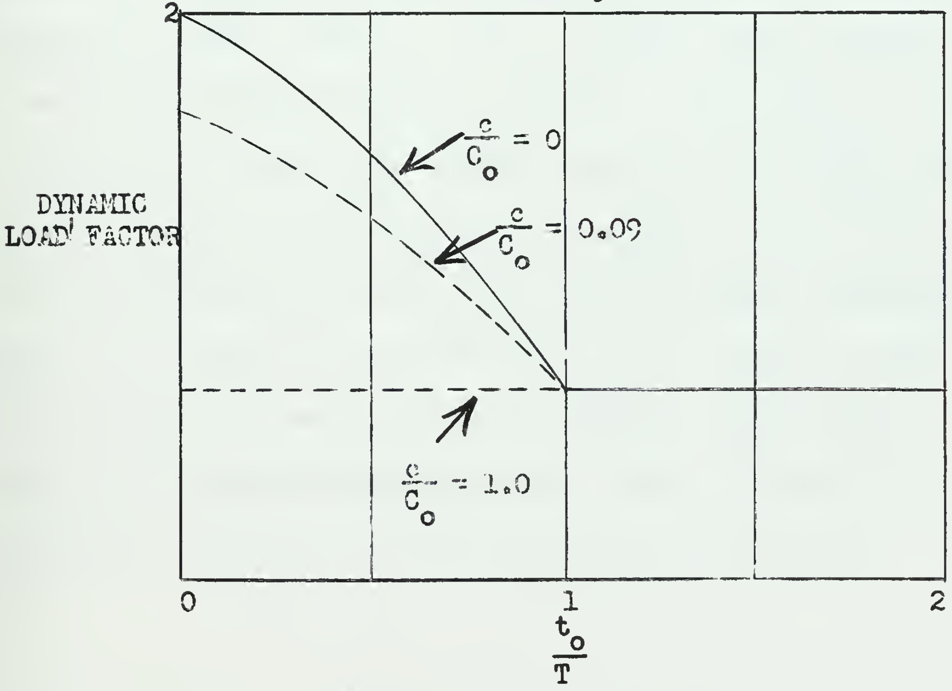
FIG. 13-A

FIGURE 13-B



TYPICAL TIME VARIATION OF IMPACT LOAD
FROM REF.(10)

FIGURE 13-C



DYNAMIC LOAD FACTORS FOR IMPACTS
OF TYPE SHOWN IN FIGURE 13-B
FROM REF.(10)

III. Results of Investigation of Planing Pressures

1. Typical results of the Slamming Pressure Investigation are presented in figures 13 and 13a. The zero pressure in these figures refers to steady planing pressure.

Additional information is included in the appendices.

2. Discussion of Results

The pressure signature during slamming was obtained for the area in which maximum slamming pressures were expected. This location was determined by N. H. Jasper (10) and CDR Peter Ducane (4), as somewhat aft of the stagnation point in steady planing. The entry point at maximum speed was observed at approximately station 2 during pre-instrumentation runs. Three pressure transducers were arranged fore and aft in the centers of the panels bounded by frames 3 and 4, 4 and 5, 5 and 6, and by stringers 1 and 2 on the port side of the boat (fig. 12). The pressure transducer at the center of this longitudinal array read consistently higher pressures during slamming than those forward and aft of it. A transverse array was then installed with the center longitudinal gage as the center of the transverse array. Again the center gage read the highest pressures during slamming. These results determine the area of maximum slamming pressures under the service full load condition at frame 4-1/2 midway between keel and chine.

Steady planing pressures were very low in the area of maximum slamming pressures. The maximum steady planing pressures at gage P5 (fig. 12) was 0.3 psi. This tends to confirm the theory that the stagnation pressure on the planing hull exists in only a very narrow area and falls off very quickly as one goes aft along the hull. CDR DuCane experienced essentially the same phenomena in his tests on a high speed rescue launch (4).

Two recording accelerometers were installed. These were arranged to read vertical accelerations at frames 0 and 5-1/2. Both of these accelerometers were attached to the most rigid member available in the area, pipe supports near the center line of the boat. Since the number of recording channels was limited, two distinct types of run were made; the first recording the two accelerations and the longitudinal pressure array, the second recording the accelerations and the transverse pressure array.

Three typical slams are shown in figures 13 and 13-A. These runs were all made at or near the maximum power setting. Under 1800 RPM there was no rapid pressure build-up to a sharp peak and no sensation of shock was felt by the operator. At 1800 and 1950 RPM, however, there was unmistakable evidence of the slamming phenomena.

The duration of the main pressure peak of the slams was surprisingly short, of the order of 0.3 seconds. This pressure peak builds up and decays quickly as it moves aft along the hull.

Though the separation between gages P5 and P6 is only two feet, the maximum pressure observed at P6 rarely exceeded fifty percent of that observed at P5. Likewise the transverse pressure during slamming tended to drop off rapidly as one progressed toward either keel or chine from the midpoint.

After the maximum pressure peak developed, the boat experienced an upward acceleration. This contained a marked pitch component since the area of high pressure was well forward. The accelerometer near the point of maximum pressure never exceeded a value of 0.35g.

The data showed no direct correlation between the measured accelerations or the acceleration of the boat's center of gravity and the maximum pressures obtained. Slamming is a local phenomena. The local effects of pressure upon the plate are not transmitted directly to the main structure of the boat. The inherent resiliency of the boat's structure may prevent these local effects from being transmitted throughout the boat.

The stagnation pressure at 20 knots is 7.88 psi. The maximum pressure obtained during our runs was 6.5 psi above atmospheric. As far as can be determined from the reports available (4) (10), neither Jasper or DuCane exceeded stagnation pressure in their experiments.

Since the most severe slamming conditions are observed when running into ahead seas, where the wave crests themselves have considerable velocity, the stagnation pressure should be calculated considering the relative velocity between wave crest and the boat.

TABLE IV

WAVE VELOCITIES IN KNOTS IN OPEN SEAS IN RELATION TO WIND STRENGTH[1]

Wind Velocity	Duration of wind in hours 10	20	30	40
10 kts	9.1	11.5	13.6	14.5
20 kts	13.3	17.6	20.3	22.4
30 kts	17.0	22.1	25.8	28.8
40 kts	20.3	26.7	30.9	34.5

[1] - from Wind, Waves & Breakers HO 602, Table 15, p. 32.

Table IV shows the wave velocities assuming open sea conditions and adequate fetch for full wave development. Conditions as severe as these are rarely encountered in the sheltered waters in which the Utility Boat is usually operated. An example of the severity of open sea conditions for planing hulls has occurred on the southern New England Coast where a forty foot boat has experienced severe failure of the bottom plating in the vicinity of station 3*.

Boats operating in similar service in areas of less well developed waves have experienced no failures.

Since slamming is a very localized phenomena, it is extremely difficult to obtain direct correlation with the gross movements of the boat. The limited number of runs made during this test series makes a statistical approach a practical impossibility.

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* - Discussion with Mr. Carl Alberg, Naval Architect, First Coast Guard District, Boston, Massachusetts

In his tests on a high speed pure planing hull, N. H. Jasper suggests a mathematical approach for obtaining a relationship between maximum pressure developed in slamming and the gross heave acceleration of the boat. His solution is based on knowledge of the approximate pressure distribution on the bottom of the hull during slamming. Knowing this, it is possible to solve the equation:

$$\int_0^L P dx = \int_0^L \frac{W}{g}\ddot{y}\, dx + \int W dx$$

P force per unit length at any point

W weight per unit length at any point

$\ddot{y}$ heave acceleration at any point.

Though this leads to an adequate solution for a pure planing hull, it is an oversimplification of the problem when applied to semi-planing hulls. A more rigorous look at the basic equation shows:

$$\int_0^L P(x,t)dx = \int_0^L \frac{W'}{g}(x,t)dx + \int_0^L W'(x,t)dx + \int_0^L f(x,t,t')dx$$

$P(x,t)$ = force per unit length at any point on the bottom. For a semi-planing hull this includes significant amounts of buoyancy, pure planing pressure, and impact pressure due to slamming.

W = the effective weight of the boat per unit length at any point and includes added mass due to hydrodynamic effects.

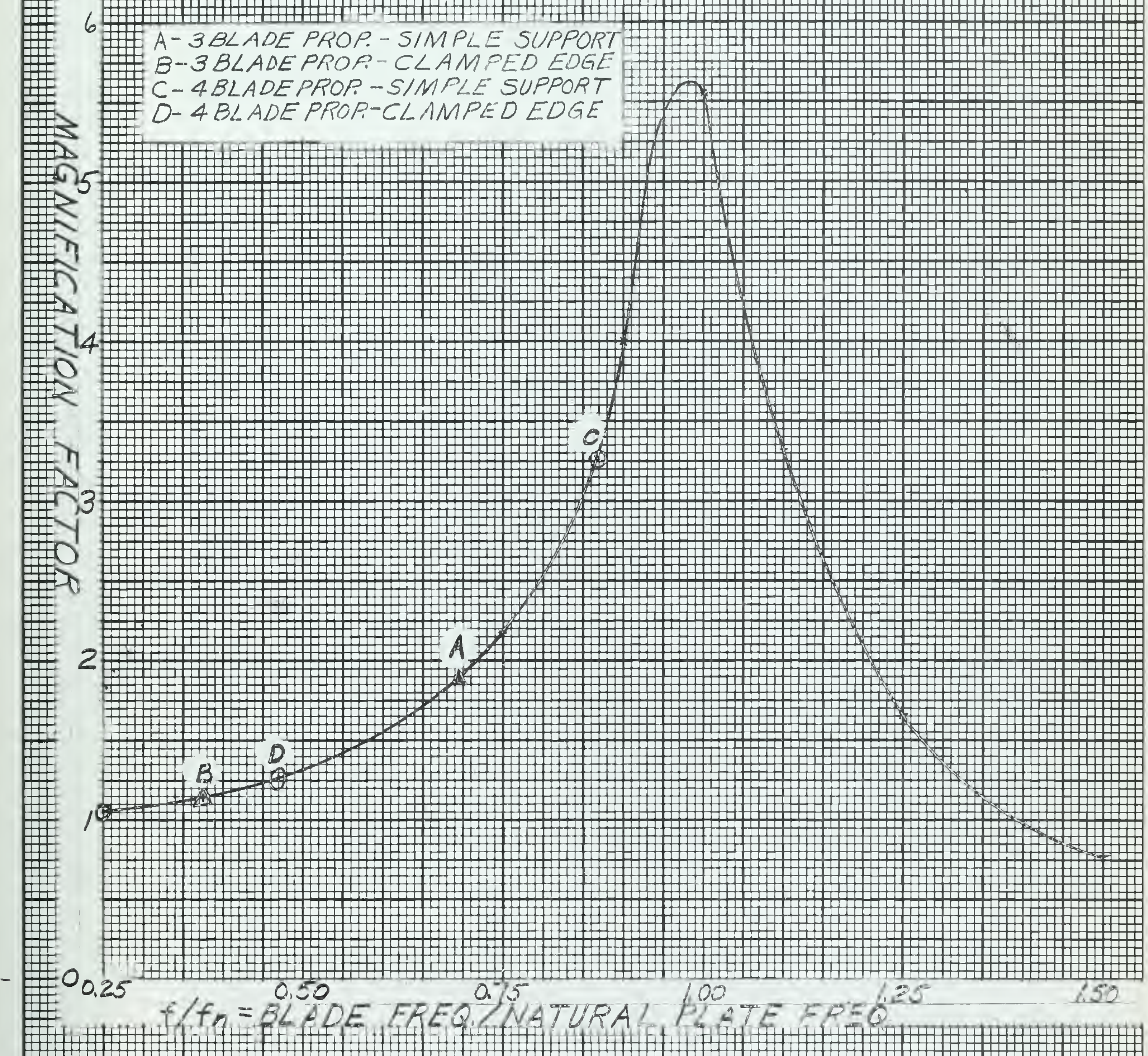
f = a damping force which acts to shift the phase between the force on the hull and the resultant acceleration. The damping force appeared highly important in our tests since the maximum of the pressure pulse was observed very near the point of zero acceleration (maximum velocity).

The slow planing hull where buoyant effects are appreciable presents a highly complex problem which does not lend itself to the type of solution proposed by N. H. Jasper for fully planing hulls. It depends for its success upon a knowledge of the force pattern upon the bottom of the boat in slamming. Since this is a very complex phenomena in semi-planing hulls it is our feeling that it cannot be extended to hulls of different characteristics unless extensive research is done concerning the pressure distribution found in service.

$$LKP_o = W(1 + \frac{\ddot{y}}{g})$$

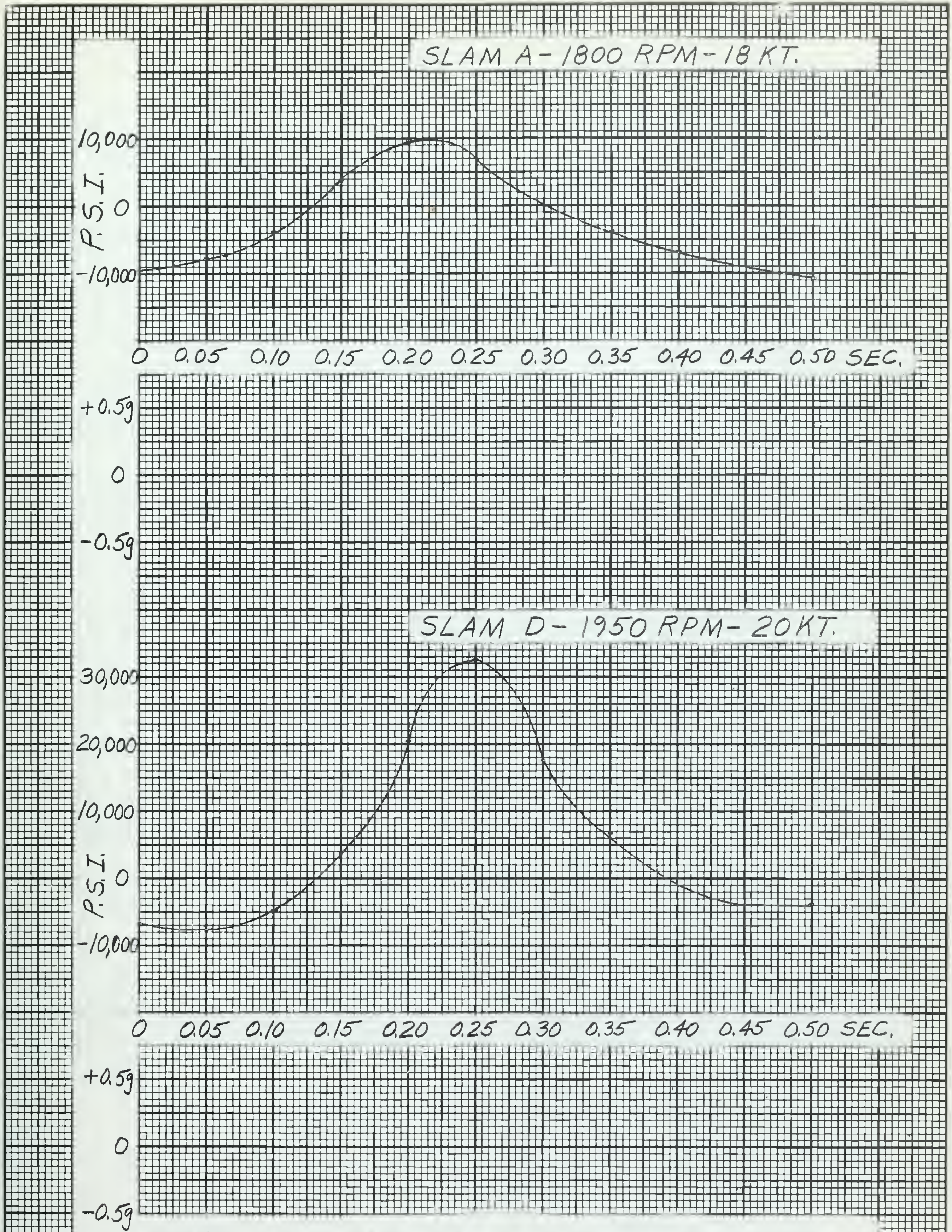
$$P_o = \frac{W(1 + \frac{\ddot{y}}{g})}{KL}$$

where $KP_o L$ = area under the curve of pressure (i.e. the total force applied to the bottom).



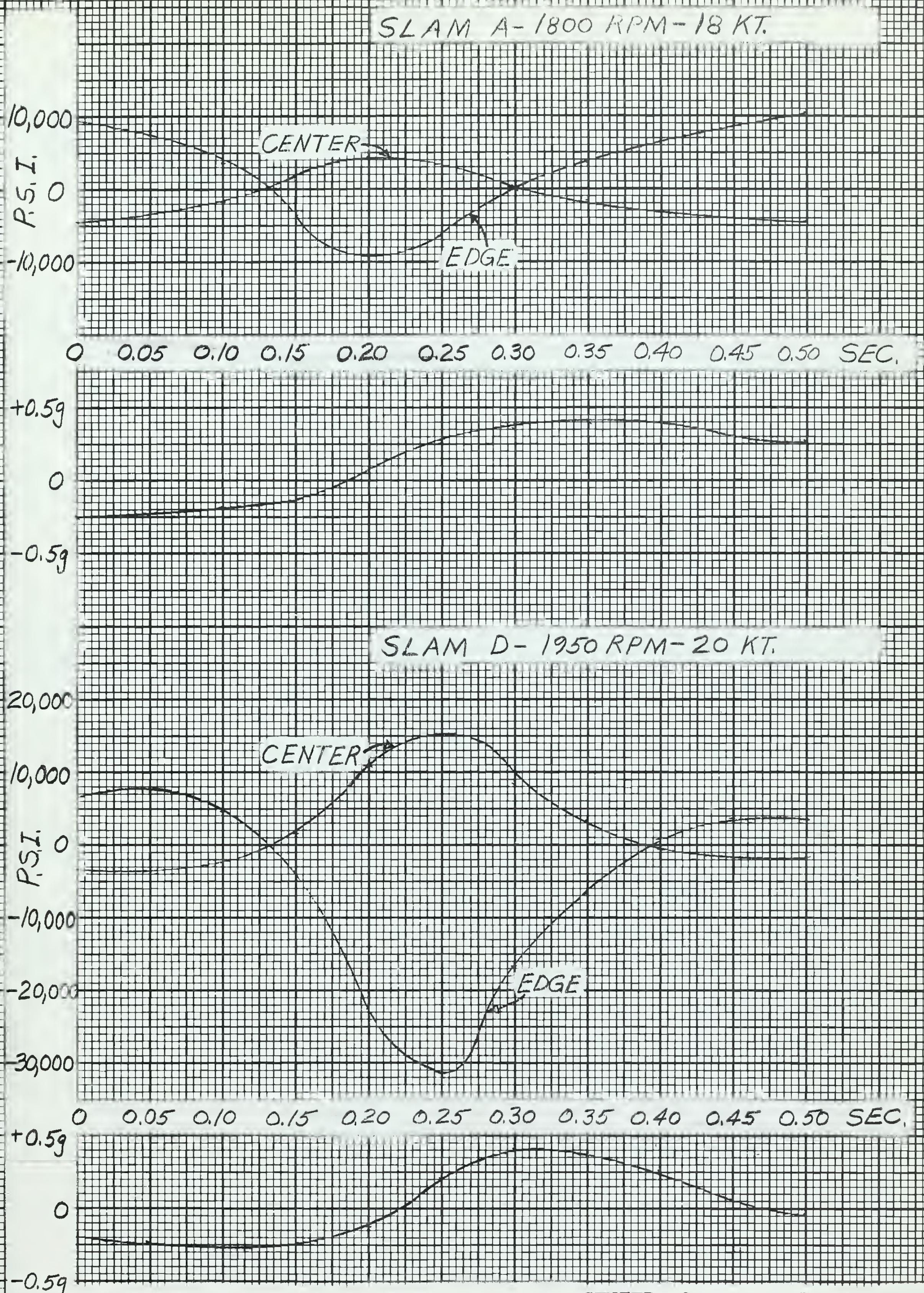
MAGNIFICATION FACTOR VS. FREQUENCY RATIO FOR AFT PANEL AT MAXIMUM SPEED FOR($\frac{c}{c_c}$=0.09)

FIGURE 14



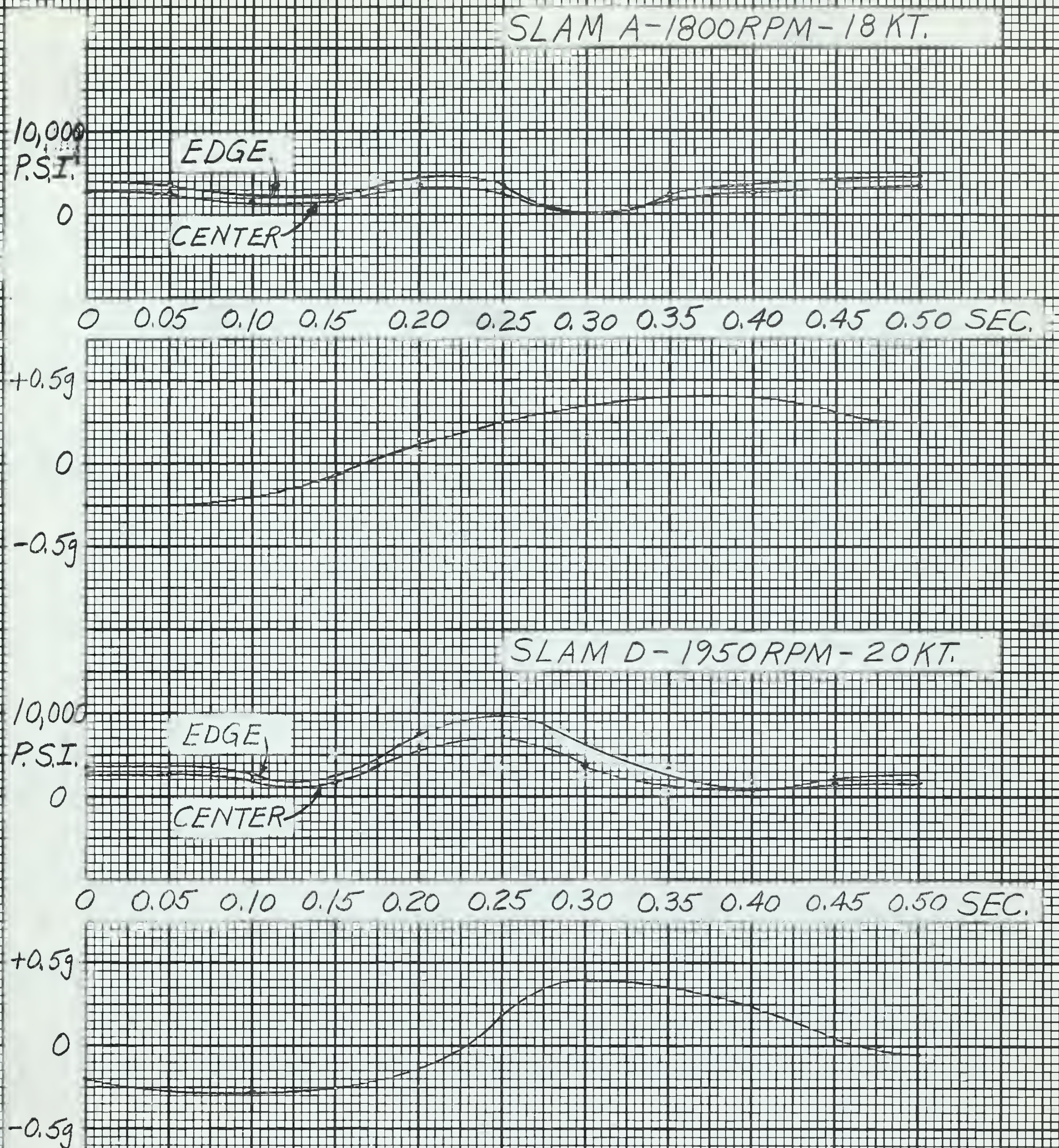
TRANSVERSE STRESS at the CENTER of the panel having maximum pressure, calculated from pressure assuming SIMPLE SUPPORT, and the Heave Acceleration of the boat at this panel vs. Time.

FIGURE 15



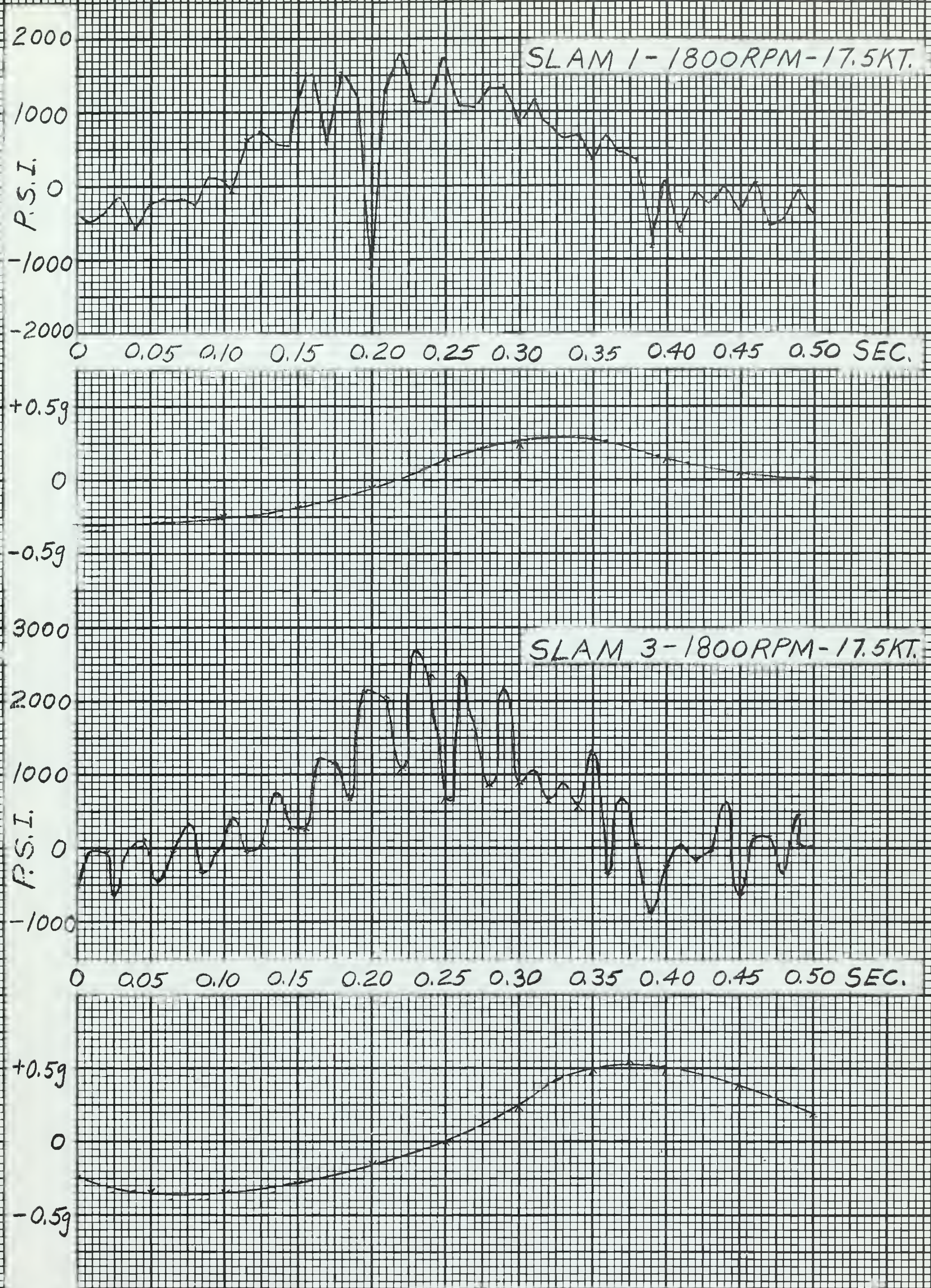
TRANSVERSE STRESS at the EDGE and at the CENTER of the panel having maximum pressure, calculated from pressure assuming FIXED EDGES & the Heave Acceleration of the boat at this panel vs. Time

FIGURE 16



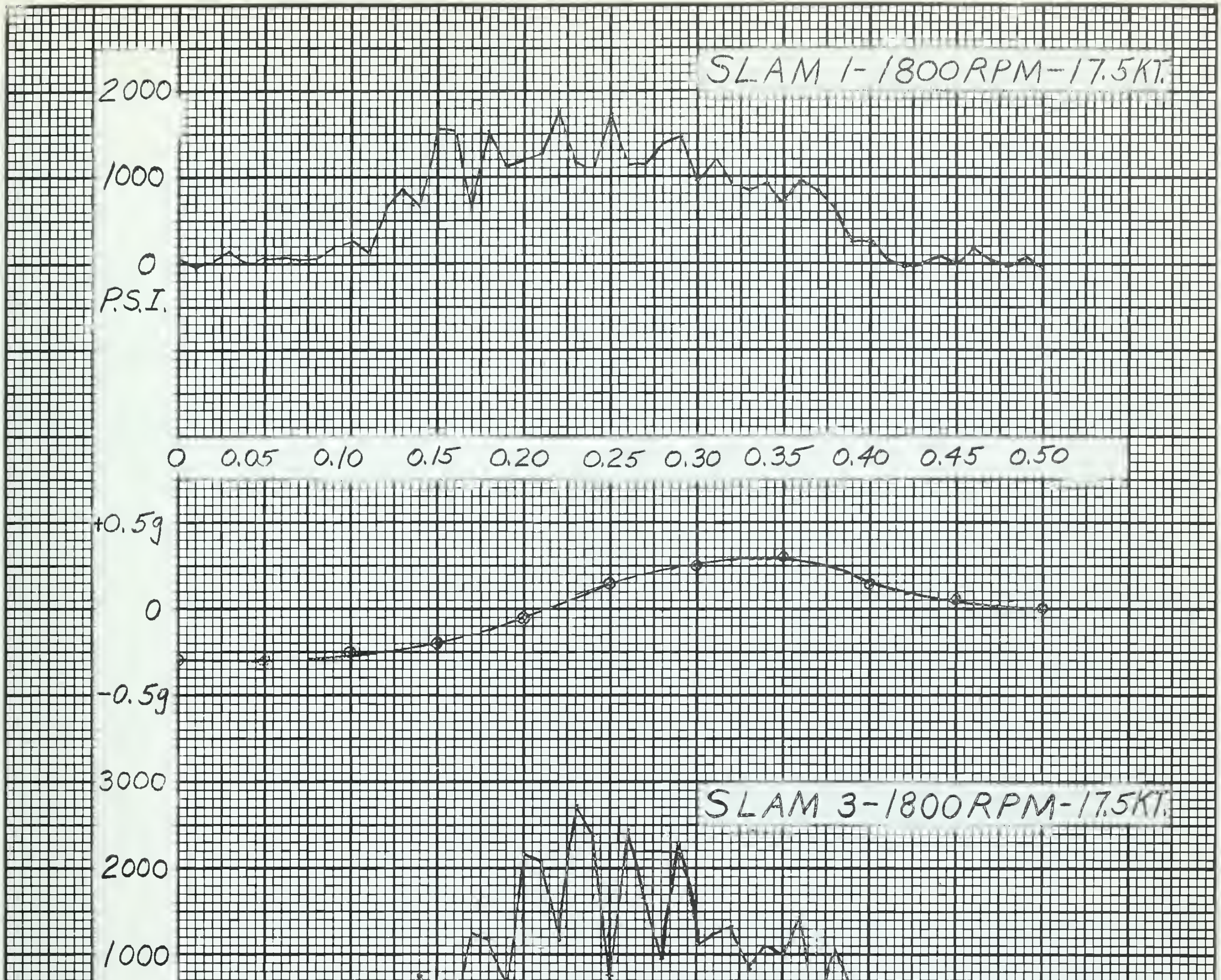
TRANSVERSE MEMBRANE STRESS at the EDGE and at the CENTER of the panel having maximum pressure, calculated from pressure, and the Heave Acceleration of the boat at this panel vs. Time.

FIGURE 17



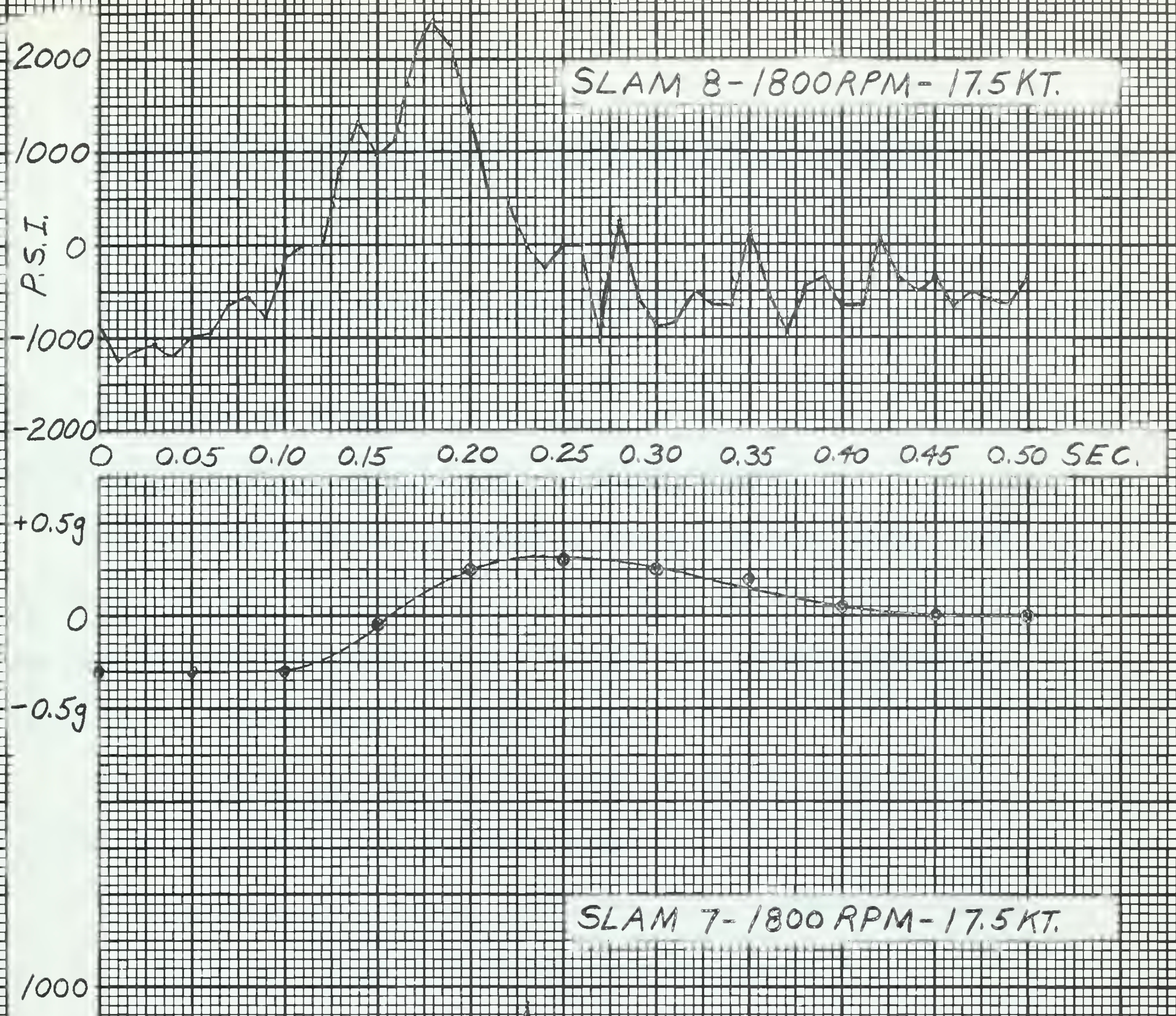
TRANSVERSE STRESS at the CENTER of the panel having maximum pressure and the Heave Acceleration of the boat at this panel vs. Time

FIGURE 18



Maximum PRINCIPAL STRESS recorded at the CENTER of the panel having maximum pressure, and the Heave Acceleration of the Boat at this panel vs. Time

FIGURE 19



TRANSVERSE STRESS on the inside surface at the midpoint of the long EDGE of the panel having maximum pressure, and the Heave Acceleration of the boat at this panel vs. Time

FIGURE 20

IV Results of Investigation of Plating Stress in Slamming

1。 The final results are presented here in graphical form。 Data and Calculations appear in the appendices。

2。 Discussion of Results

Theoretical Stress Calculated from Pressure Forward

The maximum pressure recorded in every slam was at P5。 Its location is shown in figure 12 。 Since this was the location of maximum recorded pressure, it was decided that strain readings taken in this panel would be the largest。

The following assumptions were made in the calculation of stress in this panel from pressure data:

1。 The pressure recorded at P5 during each slam was assumed to be uniformly distributed over the panel。
2。 The edges of the panel were taken to be simply supported。
3。 The dynamic load factor was taken to be unity。

From the transverse pressure distribution recorded at the longitudinal position of P5, it appears that a more reasonable value for uniformly distributed pressure on the panel containing P5 would be 90% of the maximum pressure recorded。 Because only three pressure points were recorded for transverse distribution, we can not be certain that P5 was located exactly at the peak pressure。 For this reason we did not reduce the recorded values of P5 in calculating the stresses in the panel。 It is felt that the stress values so obtained are as close to those actually existing in the panel as values calculated from a reduced value of P5。

The second assumption is not exactly correct because some fixation does occur at the edges. This assumption is discussed in more detail under measured values of strain.

Because of the uncertainty of the degree of fixity of the panel edges, it was assumed that the edges were simply supported. This gives the largest possible value of stress that can occur under actual conditions.

The value of dynamic load factor was taken as unity based on the work of Jasper (10). From the pressure-time variation recorded in slamming, we obtained a similarly shaped load curve as that analyzed by Jasper and shown here in figure (13). The results of this analysis are summarized in the curve of dynamic load factor shown in figure (13a). The calculation of dynamic load factor for this panel is shown in Appendix C. Since the dynamic load factor was found to be unity, the dynamic pressures recorded at P5 were taken as static pressures in calculation of the panel stresses.

Sample calculations of the stresses in the panel are given in Appendix D, and the results are shown in figures 15, 16, & 17. The greatest calculated stresses are at the center of the panel, assuming simple support, and are in the transverse direction. The largest recorded pressure was 5.16 psi. The largest calculated value of stress based upon a pressure loading of 5.16 psi, was found to be 42,245 psi. This value exceeds the average yield strength of mild steel of 35,000 psi. Before tests were conducted it was noted that this panel showed evidence of permanent set in that the panel was stretched.

The above calculated value of stress at the center of the panel existed over only a small area near the center and exceeded the yield stress for a very short time, not exceeding 0.07 seconds.

Measured Stress Forward

In making the tests for strain data we were able to completely record only relatively mild slams because of the sensitivity setting of the amplifiers. The weather was very poor on the day that this data was recorded, and for this reason we were required to obtain as much data as possible in the shortest possible time. Strain data aft was taken first, and it was found that to obtain a reasonably large indication on the recorder, a sensitivity of 50 micro-inches per centimeter was required. After shifting the amplifiers to the forward gages the same sensitivity was used, and this was found to be adequate up to 1600 RPM. No slams were recorded through this speed which caused maximum allowable deflection of the recorder. However, at 1800 RPM a number of slams occurred which produced the limiting deflection of the recorder. Because of the severe weather it was considered impossible to reset the amplifier sensitivity without returning to the pier. The zero position of the recorder could not be found while adjusting the instruments in the rough water existing. Therefore, the sensitivity was left as it had originally been set, and it was thought that it might be possible to estimate the value of the maximum strain by comparison with less severe slams which did not produce limiting deflections of the recorder. Subsequent weather conditions prohibited further testing.

The recorded strains showed that the forward panel was in tension both at the center and at the edges. For this reason it appears that the edge condition is more nearly that of simple support plus some membrane stress. The following table shows the calculated stresses on the inside surface for fixed edge, simply supported edge, and for a membrane, assuming a uniform pressure of 5.16 psi over the entire panel. This pressure is the largest recorded during any slam and is considered to be as great as any ever encountered in service. With the boat at rest, the amplifiers were adjusted to give zero pressure reading.

TABLE V

MAXIMUM CALCULATED STRESSES FOR DIFFERENT EDGE CONDITIONS

Edge Condition	Center	Edge
Fixed Edges	+19510 PSI	-40144 PSI
Simple Support	+42245	0
Membrane	+ 8260	+11550

From the above values and the fact that positive, or tension, strains were recorded at both the center and the edges, it can be concluded that the clamped condition is not correct and that the simply supported condition is more nearly correct. There must also be some membrane stress in order to produce the positive edge stress.

For design purposes we will be safe to assume that simply supported edges exist because this produces the greatest value of stress as long as the material is working below the yield value.

Figures 18, 19 and 20 show the measured stresses vs. time for several slams. These figures show the results of rather mild slams, but are typical of those recorded. The more severe slams exceeded the limits of the recorder as adjusted, and are not shown in the figures. The recorded data for the most severe slams are given in Appendix D.

V. RESULTS AND DISCUSSION OF DYNAMIC PRESSURES AND PLATING RESPONSE NEAR THE PROPELLERS

Measured Strains and Frequencies of Vibration Aft

The strains were measured in one of the bottom panels aft in order to determine whether the magnitude of stress in these panels exceeded the fatigue limit of the material. In all of the test runs made with 3-bladed propellers, there was never a large increase in magnitude of strain with increased propeller RPM. The highest frequency of vibration measured with 3-bladed propellers was 96 cycles per second, and the highest peak to peak amplitude of vibration was 75 micro inches per inch. This strain corresponds to a peak to peak stress variation of less than 2250 psi, only a fraction of the fatigue limit of the material.

In the test runs made with 4-bladed propellers no large increase in the magnitude of strain was experienced as the RPM of the propellers was increased. The highest measured amplitude of strain with 4-bladed propellers was 75 micro inches per inch at a maximum frequency of 120 cycles per second. The calculated natural frequency of the panel assuming simply supported edges is 138 cycles per second. With fixed edges the calculated natural frequency is 254 cycles per second.

Appendix B5 gives a summary of the frequencies of vibration and peak to peak amplitudes of strain for various propeller RPM for 3 and 4-bladed propellers.

Figure 14 shows the expected magnification factor for a plate acted on by a dynamic pressure $P \sin(2\pi ft)$. Two regions are shown on this curve which correspond to the limits for 3 and 4-bladed propellers. The upper limit of each region corresponds to simply supported edges, and the lower limit corresponds to fixed edges. The forcing frequencies used are 96 cps and 120 cps for 3 and 4-bladed propellers respectively. These are the maximum frequencies measured during the tests. The damping value for this curve is 0.09 of critical. This value was found by Jasper (10) to be appropriate. The upper limit of the 4-bladed region shows a magnification factor of 3.25.

The calculated magnification factor for the clamped edge condition is nearly the same, 1.15 and 1.25 respectively for the frequencies comparable to 3 and 4-bladed propellers at maximum operating RPM.

The experimental strains found were nearly the same in both cases. This leads to the conclusion that clamped edge conditions may be assumed for the after panels. These panels measure approximately 12 x 15 inches, as compared with approximately 24 x 16 inches in the forward part of the boat.

An alteration was made by the Coast Guard which placed intercosta stiffeners in the after panels to reduce their size to the above value in an attempt to alleviate the high incidence of plating failures aft.

VI. CONCLUSIONS

1. This boat is semi-planing and is supported 56% by dynamic forces and 44% by buoyancy effects at full power.
2. No correlation between observed maximum slamming pressures and gross heave acceleration was noted. However, these test results, in common with those of previous researchers show that stagnation pressure at any speed forms a sensible upper limit to the pressures which may be expected on the bottom plating during slamming.
3. In steady planing the longitudinal pressure distribution peaks sharply at a point near the entry and falls off very quickly as one progresses aft. The stagnation pressure exists over a very small area.
4. The durations of the slams are short, of the order of 0.5 second and the heave accelerations in slamming rarely exceeded 0.35g. The high pressures noted in slamming which approach the stagnation pressure are attributed to flow disturbances rather than to heave acceleration.
5. The stresses at the center and edges of the bottom panels in the area of max. slamming pressure show that the edge support conditions are that of simple support with a small additional membrane effect.
6. The fractures in the bottom panel in the area of maximum slamming pressure were caused by exceeding the ultimate strength at hard spots during very severe slamming and not by fatigue.

7. During normal operation the stresses in the area of maximum expected pressure are well below the fatigue limit of the material.
8. No significant slamming was noted below a power setting of 1700 RPM. Slamming became severe at power settings in excess of 1700 RPM.
9. The bottom panels near the propellers showed a vibration frequency equal to the propeller blade frequency.
10. No significant difference in the magnitude of plating strains was found between 3-bladed and 4-bladed propellers at common engine speeds.
11. There was no significant variation in the magnification factor with either 3-bladed or 4-bladed propellers as engine speed was varied from 1000 RPM to 1950 RPM. This is attributed to the support conditions of the panel edges which approach that of fixed support. These panels are smaller than those forward.
12. The peak to peak pressure variation in the propeller field was found to be less than 2.5 psi and its frequency was found to be equal to propeller blade frequency.

VII. RECOMMENDATIONS

It is recommended that the test program started by this group be continued. The results obtained thus far show that it is necessary to take simultaneous readings of pressure, strain, and accelerations in the area of maximum slamming pressures in order to obtain a relationship between dynamic pressures and plating strains. The following specific recommendations are made to solve the problem originally proposed:

1. At least 12 data channels capable of simultaneous recording against a common time base should be used. This will allow simultaneous recording of accelerations at three points in the boat, strain measurements at midpoints of two edges of the panel and one supporting member, and a three gage rosette at the panel center. The remaining force channels would be available for pressure readings at the center of the panel and selected surrounding locations. Pressure transducers should have a maximum range of 0-10 psi gage.
2. Equipment weight is critical. An investigation such as this can best be carried out using light aircraft type test equipment. The problems of weight and moment compensation, even with many more recording channels would not be as severe as those encountered by this group.
3. Further investigation should be made of the effect of damping upon the phase relationship between slamming pressure and the bodily response of the boat.

4. A comparison between the magnitudes of pressures and strains obtained by passing through "standard" waves such as those produced by wakes and those produced under severe sea conditions, should be made.

It is felt that a thorough follow up program to the investigation made thus far will yield information on the response of the semi-planing hull to rough water service which will be of great value to those engaged in the design of such craft. Instrumentation and time limitations have led this group to produce an interim report which, it is hoped, will supply the basic techniques required for the final investigation.

VIII - APPENDIX

APPENDIX "A"

SUMMARY OF TEST RUNS

Pressure Data Date: 10/4/58

Run No.	Speed rpm	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Remarks
1	1400	P1	P2	P3	P5	A1	A2	Calm water
2	1400	"	"	"	"	"	"	"
3	1600	"	"	"	"	"	"	"
4	1800	"	"	"	"	"	"	"
5	1950	"	"	"	"	"	"	"
6	1950	"	"	"	"	"	"	" "
7	1950	"	"	"	"	"	"	"
8	1400	P4	P3	P6	P5	A1	A2	CG40'BoatWake
9	1400	"	"	"	"	"	"	"
10	1600	"	"	"	"	"	"	"
11	1600	"	"	"	"	"	"	"
12	1800	"	"	"	"	"	"	"
13	1800	"	"	"	"	"	"	"
14	1950	"	"	"	"	"	"	"
15	1950	"	"	"	"	"	"	Tanker wake
16	Stopped	"	"	"	"	"	"	"
17	1950	"	"	"	"	"	"	CG40'BoatWake
18	1950	"	"	"	"	"	"	"
19	1950	P7	P3	P8	P5	A1	A2	Tanker wake
20	1950	"	"	"	"	"	"	"
21	1950	P7	A1	P8	P5	blank	A2	CG40'BoatWake
22	1950	"	"	"	"	"	"	"
23	1800	"	"	"	"	"	"	"
24	1800	"	"	"	"	"	"	"
25	1600	"	"	"	"	"	"	"
26	1600	"	"	"	"	"	"	"
27	1400	"	"	"	"	"	"	"
28	14-1950	"	"	"	"	"	"	Acceleration
29	Stopped	"	"	"	"	"	"	Calm water

Strain Data Aft With 3-Bladed Screws Date: 11/8/58

Run No.	Speed rpm	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Remarks
1	1950	A1	A2	S1	S3	S5	S4	Normal waves
2	1600	"	"	"	"	"	"	"
3	1400	"	"	"	"	"	"	"
4	1200	"	"	"	"	"	"	"
5	06-1950	"	"	"	"	"	"	Acceleration
6	1950	A1	A2	S1	S6	S5	S2	Normal waves
7	1800	"	"	"	"	"	"	"

APPENDIX "A"
SUMMARY OF TEST RUNS (cont'd.)

Strain Data Aft With 4-Bladed Screws Date: 11/22/58

Run No.	Speed rpm	Channel 1	Channel 2	Channel 3	Channel 4	Channel 5	Channel 6	Remarks
1	600	A1	A2	S1	S6	S5	S2	Normal waves
2	1400	"	"	"	"	"	"	"
3	1000	"	"	"	"	"	"	"
4	1800	"	"	"	"	"	"	"
5	1950	"	"	"	"	"	"	"
6	06-1950	"	"	"	"	"	"	"
7	600	A1	A2	S1	S3	S5	S4	"
8	1000	"	"	"	"	"	"	"
9	1400	"	"	"	"	"	"	"
10	1800	"	"	"	"	"	"	"
11	1600	"	"	"	"	"	"	"
12	1950	"	"	"	"	"	"	"
13	1400	A1	A2	S5	S4	S3	blank	"
14	1800	"	"	"	"	"	"	"
15	1600	"	"	"	"	"	"	"
16	1200	"	"	"	"	"	"	"
17	1000	"	"	"	"	"	"	"
18	600	"	"	"	"	"	"	"
19	1800	A1	A2	S1	S2	S6	blank	"
20	1400	"	"	"	"	"	"	"
21	1000	"	"	"	"	"	"	"

APPENDIX "B"

1.

PRESSURE DATA FORWARD(1)

SLAM A, Run 12, 10/4/58, 1800 RPM

Time	A1	A2	P4	P5	P6
0 sec.	-0.250	-0.333	-0.476	-1.192	-0.238
0.05	-0.250	-0.333	-0.357	-0.952	-1.310
0.10	-0.200	-0.217	0	-0.480	0
0.15	-0.067	0	0.715	0.476	0
0.20	0.150	0.233	0.715	1.200	0.238
0.25	0.250	0.366	0	0.840	0
0.30	0.350	0.600	0	0	0
0.35	0.400	0.600	0.238	-0.480	0.118
0.40	0.400	0.600	-0.456	-0.840	0.118
0.45	0.300	0.466	-0.456	-1.100	0.118
0.50	0.250	0.333	-0.572	-1.320	0.118

SLAM B, Run 14, 10/4/58, 1950 RPM

Time	A1	A2	P4	P5	P6
0 sec.	0	0	0	0	0
0.05	0.150	0.200	0.25	1.080	0.15
0.10	0.100	0.130	-0.50	0.840	0
0.15	0	-0.067	-1.00	-1.440	-0.25
0.20	-0.050	-0.130	-1.00	-1.682	-0.38
0.25	-0.050	-0.067	-0.50	-0.600	-0.25
0.30	+0.050	-0.067	0	0.960	0.25
0.35	0.250	0.230	2.18	3.120	0.75
0.375	0.350	0.430	2.18	4.800	1.20
0.40	0.350	0.430	1.45	3.360	0.75
0.45	0.300	0.330	0	0	0
0.50	0.25			0.720	

SLAM C, Run 15, 10/4/58, 1950 RPM

Time	A1	A2	P4	P5	P6
0 sec.	-0.250	-0.333	-0.72	-1.662	-0.24
0.05	-0.300	-0.400	-0.48	-1.560	-0.24
0.10	-0.30	-0.400	-0.48	-1.182	-0.24
0.15	-0.250	-0.400	-0.24	-0.482	-0.24
0.20	0	-0.133	0.24	0.600	0
0.25	0.150	0.267	0.96	1.198	0.24
0.30	0.100	0.267	0	1.080	0.24
0.35	0.100	0.267	-0.24	0.360	0.24
0.40	0.050	0.067	-0.48	-0.242	0
0.45	0	0	-0.48	-0.722	-0.24
0.50	0.100	0.133	-0.48	-0.962	-0.24

(1) - Zero reference for pressure data taken with boat at rest.

1. PRESSURE DATA FORWARD(1) (cont'd.)

SLAM E, Run 21, 10/4/58, 1950 RPM

Time	A1	A2	P5	P7	P8
0 sec	0	0	-0.360	-0.358	0.596
0.05	-0.100	-0.133	-0.600	-0.358	0.596
0.10	-0.167	-0.333	-0.720	-0.358	0.596
0.15	-0.233	-0.333	-0.600	-0.358	0.596
0.20	-0.233	-0.267	-0.240	-0.358	0.596
0.25	-0.200	-0.100	1.440	-0.715	0.834
0.30	-0.200	0	3.12	-0.834	1.548
0.35	-0.200	0	2.160	-0.596	2.258
0.40	-0.250	-0.133	-1.440	-0.358	1.135
0.45	-0.267	-0.400	-1.440	-0.358	0.596
0.50	-0.100	-0.067	3.120	-1.072	0.596
0.55	0.133	0.333	5.160	-1.072	2.738
0.60	0.300	0.600	2.880	-0.834	1.980
0.65	0.300	0.534	1.200	-0.358	1.135
0.70	0.250	0.466	-0.240	-0.358	0.596
0.75	0.200	0.400	-0.600	-0.358	0.596
0.80	0.200	0.333	-0.720	-0.358	0.358

SLAM F, Run 23, 10/4/58, 1800 RPM

Time	A1	A2	P5	P7	P8
0 sec	-0.400	-0.466	-1.44	0.118	-0.118
0.05	-0.367	-0.433	-0.36	0.118	-0.118
0.10	-0.333	-0.333	-0.120	-0.120	0
0.15	-0.150	0.267	0	-0.358	-0.118
0.20	0.053	0.666	4.56	-1.014	-0.118
0.25	0.333	0.666	4.08	-0.715	2.738
0.30	0.400	0.666	1.44	-0.120	1.548
0.35	0.266	0.467	-0.240	0.047	0.668
0.400	0.200	0.368	-0.60	-0.120	0.239
0.45	0.167	0.333	-0.84	-0.120	0.120
0.500	0.167	0.267	-0.96	-0.239	0.120

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(1) - Zero reference for pressure data taken with boat at rest.

2. THEORETICAL STRESS CALCULATED FROM PRESSURE DATA(1)

ASSUMING STATIC PRESSURES
CLAMPED EDGES

SLAM A, Run 12, 10/4/58, 1800 RPM

Time	P5	$(x)_o$	$(y)_o$	$(x)^{a/2}$	$(y)^{b/2}$
0 sec	-1.19	-4498	-2437	+9258	+6997
0.05	-0.95	-3591	-1946	+7393	+5586
0.10	-0.48	-1815	- 983	+3735	+2822
0.15	+0.48	+1815	+ 983	-3735	-2822
0.20	+1.20	+4536	+2458	-9336	-7056
0.25	+0.84	+3175	+1720	-6535	-4939
0.30	0	0	0	0	0
0.35	-0.48	-1815	- 983	+3735	+2822
0.40	-0.84	-3175	-1720	+6535	+4939
0.45	-1.10	-4158	-2252	+8558	+6468
0.50	-1.32	-4990	-2703	+10270	+7761

SLAM B, Run 14, 10/4/58, 1950 RPM

0 sec	0	0	0	0	0
0.05	+1.08	+4083	+2219	-8402	-6350
0.10	+0.84	+3175	+1720	-6535	-4939
0.15	-1.44	-5773	-2949	+11203	+8467
0.20	-1.68	-6350	-3440	+13071	+9878
0.25	-0.60	-2268	-1229	+22401	+3528
0.30	+0.96	+3629	+1966	-7470	-5645
0.35	+3.12	+11800	+6389	-24896	-18345
0.375	+4.80	+18150	+9830	-37350	-28224
0.40	+3.36	+12700	+6881	-26140	-19757
0.45	0	0	0	0	0
0.50	+0.72	+ 2722	+1475	-5601	-4234

SLAM C, Run 15, 10/4/58, 1950 RPM

0 sec	-1.66	-6275	-3399	+12920	+9761
0.05	-1.56	-5897	-3195	+12142	+9173
0.10	-1.18	-4460	-2416	+9180	+6938
0.15	-0.48	-1815	- 983	+3735	+2822
0.20	+0.60	+2268	+1229	-4668	-3528
0.25	+1.20	+4536	+2458	-9336	-7056
0.30	+1.08	+4082	+2219	-8402	-6350
0.35	+0.36	+1361	+ 737	-2800	-2117
0.40	-0.24	- 907	- 491	+1867	+1411
0.45	-0.72	-2722	-1475	+5601	+4234
0.50	-0.96	-3629	-1966	+7470	+5645

$(x)_o$ = Stress at center in direction of short dimension.

$(y)_o$ = Stress at center in direction of long dimension.

$(x)a/_2$ = Stress at midpoint of the long edge.

$(y)b/_2$ = Stress at midpoint of the short edge.

(1) - Zero reference for pressure data taken with boat at rest.

2. THEORETICAL STRESS CALCULATED FROM PRESSURE DATA(1)

ASSUMING STATIC PRESSURES(cont'd)
CLAMPED EDGES

SLAM D, Run 19, 10/4/58, 1950 RPM

Time	P5	$(x)_o$	$(y)_o$	$(x)^{a/2}$	$(y)^{b/2}$
0 sec	-0.84	-3175	-1720	+6535	+4939
0.05	-0.96	-3629	-1966	+7470	+5645
0.10	-0.60	-2268	-1221	+4668	+3528
0.15	+0.47	+1777	+ 963	-3658	-2763
0.20	+2.88	+10880	+5898	-22406	-16934
0.25	+4.00	+15120	+8192	-31120	-23520
0.30	+2.15	-8127	+4403	-16726	-12642
0.35	+0.84	+3175	+1720	-6535	-4939
0.40	-0.12	- 454	- 245	+ 934	+ 706
0.45	-0.48	-1815	- 983	+3735	+2822
0.50	-0.48	-1815	- 983	+3735	+2822

SLAM E, Run 21, 10/4/58, 1950 RPM

Time	P5	$(x)_o$	$(y)_o$	$(x)^{a/2}$	$(y)^{b/2}$
0 sec	-0.36	-1361	- 737	+2800	+2117
0.05	-0.60	-2268	-1229	+4668	+3528
0.10	-0.72	-2722	-1475	+5601	+4234
0.15	-0.60	-2268	-1229	+4668	+3528
0.20	-0.24	- 907	- 491	+1867	+1411
0.25	+1.44	+5443	+2949	-11203	-8467
0.30	+3.12	+11800	+6389	-24896	-18345
0.35	+2.16	+8165	+4424	-16804	-12700
0.40	-1.44	-5443	-2949	+11203	+8467
0.45	-1.44	-5443	-2949	+11203	-8467
0.50	+3.12	+11800	+6389	-24896	-18345
0.55	+5.16	+19510	+10568	-40144	-30340
0.60	+2.88	+10880	+5898	-22406	-16934
0.65	+1.20	+4536	+2458	-9336	-7056
0.70	-0.24	- 907	- 491	+1867	+1411
0.75	-0.60	-2268	-1229	+4668	+3528
0.80	-0.72	-2722	-1475	+5601	+4234

$(x)_o$ = Stress at center in direction of short dimension.

$(y)_o$ = Stress at center in direction of long dimension.

$(x)a/_2$ = Stress at midpoint of the long edge.

$(y)b/_2$ = Stress at midpoint of the short edge.

(1) - Zero reference for pressure data taken with boat at rest.

2. THEORETICAL STRESS CALCULATED FROM PRESSURE DATA$^{(1)}$

ASSUMING STATIC PRESSURES(cont'd)

CLAMPED EDGES

SLAM F, Run 23, 10/4/58, 1800 RPM

Time	P5	$(x)_o$	$(y)_o$	$(x)^{a/2}$	$(y)^{b/2}$
0 sec	-1.44	+5443	-2949	+11203	+8467
0.05	-0.36	+1361	- 737	+2800	-2117
0.10	-0.12	- 453	- 245	+ 934	- 706
0.15	0	0	0	0	0
0.20	+4.56	+17237	+9339	-35482	-26813
0.25	+4.08	+15420	+8356	-31742	-23990
0.30	+1.44	+5443	+2949	-11203	-8467
0.35	-0.24	- 907	- 491	+1867	+1411
0.40	-0.60	-2268	-1221	+4668	+3528
0.45	-0.84	-3175	-1720	+6535	+4939
0.50	-0.96	-3629	-1966	+7470	+5645

$(x)_o$ = Stress at center in direction of short dimension.

$(y)_o$ = Stress at center in direction of long dimension.

$(x)a/_2$ = Stress at midpoint of the long edge.

$(y)b/_2$ = Stress at midpoint of the short edge.

(1) - Zero reference for pressure data taken with boat at rest.

3.

STRAIN AND STRESS DATA FOR THE CENTER OF FORWARD PANEL

Slam 1, Run 14, 11/22/58, 1800 RPM

Time sec.	Al	ε_4 (1)	ε_3	ε_5	σ_x (2)	$\sigma_{(max.prim.)}$	ϕ (3)
0	-0.30g	+2	+5	-12	-375	+67	+27°
0.01		0	+3	-15	-494	-23	+27
0.02		+2	+3	-12	-330	+31	+24
0.03		+2	+6	- 5	-145	+126	+32
0.04		0	+5	-18	-592	- 1	+28
0.05	-0.30g	0	+5	- 7	-231	+62	+33
0.06		0	+5	- 5	-165	+75	+35
0.07		0	+3	- 5	-165	+32	+32
0.08		0	+5	- 7	-231	+62	+33
0.09		-2	+7	+ 4	+112	+197	+58
0.10	-0.25g	0	+10	+ 3	+ 99	+263	+50
0.11		0	+7	- 3	- 99	+134	+39
0.12		0	+12	+20	+658	+663	+84
0.13		0	+20	+25	+823	+872	+74
0.14		0	+18	+18	+592	+679	+67
0.15	-0.20g	-6	+32	+48	+1520	+1572	+78
0.16		-7	+28	+48	+1510	+1536	+82
0.17		-3	+13	+19	+595	+621	+77
0.18		-5	+18	+48	+1530	+1538	-86
0.19		0	+18	+37	+1220	+1219	-89
0.20	-0.05g	-5	+15	-33	-1135	+34	+33
0.21		-6	+15	+40	+1260	+1261	-87
0.22		-8	+20	+57	+1800	+1807	-86
0.23		-5	+14	+37	+1117	+1172	-87
0.24		-5	+15	+35	+1111	+1104	0
0.25	+0.15g	-7	+18	+54	+1710	+1722	-84
0.26		-5	+8	+35	+1090	+153	-80
0.27		-8	+2	+35	+1075	+ 16	-75
0.28		-6	+7	+42	+1325	+162	-77
0.29		-5	+5	+43	+1370	+173	-74
0.30	+0.25g	-2	-2	+26	+836	+ 57	-67
0.31		-4	+6	+36	+1150	+169	-76
0.32		0	+2	+25	+823	+158	-69
0.33		+4	-2	+19	+665	+136	-59
0.34		+4	-4	+20	+698	+101	-58
0.35	+0.30g	+10	-7	+ 7	+330	+ 4	-42
0.36		+8	-5	+17	+639	+118	-52
0.37		+8	-7	+12	+474	+ 33	-48
0.38		+6	-5	+10	+388	+ 39	-49
0.39		+13	-8	-20	-860	-544	- 7
0.40	+0.15g	+7	+1	0	+ 69	+ 50	-17

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

(3) - Angle of max.principal stress measured from fore & aft direction.

3. STRAIN AND STRESS DATA FOR THE CENTER OF FORWARD PANEL (cont'd.)

Slam 1, Run 14, 11/22/58, 1800 RPM

Time sec	Al	ε_4 (1)	ε_3	ε_5	σ_x (2)	σ (max. prim.)	ϕ (3)
0.41	+0.15g	+7	-5	-21	-622	-626	+ 4
0.42		0	0	- 3	- 99	-113	+22
0.43		+2	-2	- 7	-214	-211	+ 3
0.44		0	+4	0	0	- 92	+45
0.45	+0.05g	+2	-7	-10	-310	-326	-13
0.46		+2	-5	0	+ 20	- 97	-40
0.47		+5	0	-17	-510	-546	+14
0.48		+3	-1	-14	-431	-457	+13
0.49		+2	-2	- 2	- 46	- 65	-22
0.50	0	+2	-1	-12	-375	-400	+14

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

(3) - Angle of max. principal stress measured from fore & aft direction.

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL

Slam 2, Run 14, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_4^{(1)}$	ε_3	ε_5	$\sigma_x^{(2)}$	$\sigma_{(Max.Prim)}$	ϕ
0 sec	-0.40g	-2	+8	-4	-150	+126	+42°
0.01		+2	+5	-7	-211	+94	+29
0.02		+2	+8	-9	-277	+144	+32
0.03		+7	-7	-12	-326	+135	-12
0.04		+7	-23	-12	-326	+414	-33
0.05	-0.30g	+12	-48	-14	-342	+1082	-37
0.06		+30	-15	-5	+132	+1287	-28
0.07		-50	+130	+150	+4450	+5098	+70
0.08		-100	-80	-50	-2640	-2625	-84
0.09		-90	-120	-130	-5170	-4198	-13
0.10	+0.20g	+13	+10	+75	+2600	+2947	-66
0.11		0	+135	+135	+4450	+5095	+67
0.12		-50	-40	-50	-2140	-1912	+45
0.13		-135	-120	-128	-5550	-5358	+53
0.14		-50	-15	-125	-4610	-1866	+31
0.15	+0.45g	0	+110	+140	+4610	+4860	+75
0.16		+20	-10	0	+198	+944	-31
0.17		-20	+20	+50	+1450	+1458	+85
0.18		+25	+20	+45	+1730	+1916	-61
0.19		+5	+20	+10	+379	+615	+50
0.20	+0.40g	-15	+5	-5	-313	-63	+54
0.21		-10	+10	0	-99	+150	+54
0.22		-15	+10	+75	+2320	+2422	-78
0.23		0	0	-25	-824	-127	+22
0.24		-5	+20	+25	+775	+844	+73
0.25	+0.25g	+30	-20	+25	+1120	+2276	-43
0.26		+5	+5	-7	-181	+152	+22
0.27		0	-5	-25	-824	-199	+15
0.28		-5	-10	+20	+610	+817	-62
0.29		+5	+15	+10	+378	+503	+54
0.30	+0.15g	+5	-18	-47	-1500	-296	+ 3
0.31		-10	+15	+38	-1155	+1154	+88
0.32		0	+10	0	0	+230	+45
0.33		+6	-15	-15	-455	+149	-22
0.34		+13	+12	-15	-366	+398	+21
0.35	+0.05g	+2	+15	+30	+1010	+1009	-87
0.36		-5	+5	-17	-610	-77	+34
0.37		0	0	-10	-330	-51	+22
0.38		0	0	0	0	0	0
0.39		0	0	-13	-428	-66	+22
0.40	0	+10	+10	-45	-1385	+147	+22

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL (cont'd.)

Slam 2, Run 14, 11/22/58, 1800 RPM

Time	Al	ε_4(1)	ε_3	ε_5	σ_x(2)	σ(Max.Prim)	ϕ
0.41 SEC.	0	0	+16	+21	+692	+723	+76
0.42		+5	+3	-10	-280	+107	+18
0.43		-6	+5	-20	-718	-111	+34
0.44		0	-3	0	0	+69	-45
0.45	-0.05g	0	+5	-5	-165	+75	+35
0.46		-4	+5	-8	-304	0	+39
0.47		+7	+2	-20	-590	+89	+16
0.48		+5	+18	+10	+379	+570	+51
0.49		+2	+5	-20	-640	+25	+25
0.50	-0.10g	-5	+5	-10	-379	-27	+39

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL

Slam 3, Run 14, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_4^{(1)}$	ε_3	ε_5	$\sigma_x^{(2)}$	$\sigma_{(Max.Prim)}$	ϕ
0 sec.	-0.25g	+ 3	+ 3	-21	- 663	+ 5	+22°
0.01		+ 3	+ 2	- 3	- 69	+ 83	+16
0.02		+ 3	+ 5	- 3	- 69	+ 134	+29
0.03		+ 2	+ 3	-20	- 640	- 10	+23
0.04		+ 2	+ 3	- 1	- 13	+ 88	+29
0.05	-0.30g	+ 2	+ 5	+ 3	+ 119	+ 165	+50
0.06		+ 3	+ 5	-15	- 465	+ 70	+25
0.07		+ 3	+ 3	- 3	- 69	+ 97	+22
0.08		+ 2	+ 6	+ 9	+ 316	+ 317	+85
0.09		+ 2	+ 6	-10	- 310	+ 97	+29
0.10	-0.35g	+ 1	+ 5	- 2	- 56	+ 110	+37
0.11		+ 2	+ 5	+12	+ 415	+ 424	-79
0.12		+ 3	+ 7	- 2	- 36	+ 182	+34
0.13		+ 2	+ 5	0	+ 20	+ 138	+37
0.14		+ 2	+ 8	+22	+ 745	+ 762	-79
0.15	-0.25g	+ 3	+12	+ 8	+ 294	+ 396	+55
0.16		+ 2	+10	+ 7	+ 251	+ 332	+57
0.17		- 1	+12	+37	+1210	+1231	-81
0.18		+ 2	+14	+35	+1173	+1187	-82
0.19		+ 2	+10	+20	+ 680	+ 680	-86
0.20	-0.15g	- 5	+25	+67	+2160	+2170	-85
0.21		- 7	+27	+65	+2075	+2074	-88
0.22		0	+10	+35	+1155	+1189	-78
0.23		-10	+33	+85	+2705	+2708	-87
0.24		-10	+35	+75	+2375	+2375	+88
0.25	0	+ 4	+ 5	+20	+ 700	+ 759	-69
0.26		- 8	+20	+75	+2395	+2442	-80
0.27		0	+18	+50	+1650	+1670	-82
0.28		+ 4	+ 5	+25	+ 865	+ 948	-68
0.29		- 5	+13	+68	+2195	+2294	-76
0.30	+0.25g	+ 6	- 2	+25	+ 885	+1123	-59
0.31		+ 5	0	+30	+1040	+1246	-62
0.32		+ 4	- 5	+30	+1030	+1318	-60
0.33		+ 3	- 4	+18	+ 624	+ 826	-58
0.34		0	- 5	+27	+ 890	+1107	-63
0.35	+0.50g	+ 4	-15	+15	+ 535	+ 986	-51
0.36		- 3	0	+41	+1323	+1485	-69
0.37		+ 7	-11	-13	- 360	+ 166	-19
0.38		+ 5	- 8	+20	+ 700	+1039	-55
0.39		+15	- 7	- 3	+ 50	+ 622	-27
0.40	+0.50g	+16	- 5	-32	- 897	+ 215	+ 3

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL (cont'd.)

Slam 3, Run 14, 11/22/58, 1800 RPM

Time	Al	ε_4 (1)	ε_3	ε_5	σ_x (2)	$\sigma_{(Max.Prim)}$	ϕ
0.41 Sec.	+0.50g	+12	- 2	-12	-277	+280	- 4
0.42		+ 7	-10	0	+ 69	+471	-37
0.43		- 1	- 1	- 5	-175	- 63	+22
0.44		- 4	- 3	0	- 40	- 34	-76
0.45	+0.40g	-11	+ 3	+22	+617	+620	-85
0.46		- 7	- 3	-18	-663	-282	+29
0.47		- 8	+ 8	+ 8	+185	+261	+67
0.48		- 7	+ 2	+ 8	+195	+197	+84
0.49		- 5	0	- 8	-314	-124	+38
0.50	+0.20g	- 2	- 4	+ 2	+ 46	+103	-58

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL

Slam 4, Run 14, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_4^{(1)}$	ε_3	ε_5	$\sigma_x^{(2)}$	σ (Max.Prim)	ϕ
0 sec.	-0.45g	- 1	+ 7	- 3	- 198	+ 123	+41°
0.01		+ 2	+ 9	- 5	- 185	+ 191	+35
0.02		+ 3	+ 12	- 10	- 271	+ 237	+33
0.03		+ 3	+ 10	- 3	- 40	+ 240	+36
0.04		+ 1	+ 18	+ 12	+ 406	+ 572	+57
0.05	-0.50g	+ 2	+ 19	0	+ 20	+ 458	+43
0.06		0	+ 15	+ 17	+ 561	+ 611	+71
0.07		+ 2	+ 10	+ 8	+ 284	+ 348	+60
0.08		- 2	+ 12	+ 10	+ 310	+ 402	+63
0.09		- 9	- 6	+ 8	+ 175	+ 212	-73
0.10	-0.50g	-15	- 10	+ 17	+ 412	+ 490	-72
0.11		-10	- 8	- 4	- 112	- 227	-80
0.12		0	- 7	- 12	- 392	- 116	- 4
0.13		+ 7	- 6	- 10	- 261	+ 157	-13
0.14		+17	- 3	- 25	- 657	+ 313	+ 1
0.15	-0.40g	+12	+ 5	- 33	- 970	+ 180	+17
0.16		+ 4	- 32	- 27	- 851	+ 100	-26
0.17		- 4	- 62	- 20	- 700	+ 654	-40
0.18		- 6	- 85	+ 13	+ 370	+2204	-48
0.19		-35	- 25	+110	+3283	+3816	-69
0.20	0	-45	+110	+110	+ 322	+3922	+67
0.21		-125	-115	-125	- 536	-5126	+45
0.22		-25	- 80	-135	- 470	-2159	0
0.25	+0.60g	*	*	*			
0.30	+1.00g						
0.35	+1.00g						
0.40	+0.60g						
0.45	+0.30g						
0.50	+0.20g	*	*	*			
0.55	+0.15g	-122	-120	-135	- 566	-5260	+26
0.56		- 10	+ 10	0	- 99	+ 150	+54
0.57		+ 18	+140	+145	+ 496	+5485	+68
0.58		- 10	+150	+145	+ 469	+5504	+66
0.59		0	- 15	0	0	+ 346	-45
0.60	+0.10g	- 20	+ 35	+ 25	+ 627	+1019	+62
0.61		- 10	+ 35	+ 50	+1551	+1631	+76
0.62		- 10	+ 35	0	- 99	+ 715	+48
0.63		0	+ 35	+ 50	+1650	+1692	+79
0.64		0	+ 5	+ 10	+ 330	+ 329	0
0.65	0	- 15	+ 45	+105	+3316	+3313	0

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL (cont'd.)

Slam 4, Run 14, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_4^{(1)}$	ε_3	ε_5	$\sigma_x^{(2)}$	$\sigma_{(\text{Max.Prim})}$	ϕ
0.66 SEC.	0	0	+20	+25	+ 825	+ 872	+74
0.67		-10	+20	+50	+1551	+1549	0
0.68		+25	0	-25	- 577	+ 576	0
0.69		0	+30	+30	+ 990	+1132	+67
0.70	-0.10g	+30	-10	-25	- 528	+ 804	-12
0.71		+10	+47	+30	+1089	+1521	+55
0.72		+15	+10	-50	-1502	+ 232	+20
0.73		0	+10	+25	+ 825	+ 829	-84
0.74		- 5	-12	-10	- 380	- 202	-30
0.75	-0.15g	0	+10	+25	+ 825	+ 829	-84

(1) - All strains are in micro-inches per inch

(2) - All stresses are in pounds per square inch.

* - Strain exceeded the limit of the instruments (greater than 125 micro-inches per inch).

3. STRAIN AND STRESS DATA FOR THE CENTER OF THE FORWARD PANEL

Slam 5, Run 15, 11/22/58, 1600 RPM

Time	**Al**	ε_4 (1)	ε_3	ε_5	σ_x (2)	σ (Max.Prim)	ϕ
0 sec.	-0.15g	0	- 7	-13	-429	-128	- 2°
0.01		0	- 7	-12	-396	-116	- 4
0.02		- 1	- 8	-15	-505	-181	0
0.03		0	- 8	-12	-396	-111	- 9
0.04		0	-11	-14	-462	-113	-14
0.05	0	0	-12	-12	-396	- 61	-22
0.06		- 1	-13	-16	-540	-162	-15
0.07		- 2	-12	-11	-333	-114	-25
0.08		- 4	-14	-16	-568	-262	-16
0.09		- 5	-14	-13	-479	-237	-25
0.10	+0.15g	- 5	-15	-17	-611	-305	-16
0.11		- 5	-14	-11	-413	-188	-31
0.12		- 4	-17	-22	-766	-329	-11
0.13		- 7	-15	-20	-729	-424	- 6
0.14		- 8	-15	-23	-838	-490	+ 1
0.15	+0.15g	-10	-14	-17	-660	-496	- 4
0.16		- 9	-18	-19	-716	-452	-19
0.17		-10	-15	-10	-429	-313	-45
0.18		- 9	-11	- 5	-254	-196	-58
0.19		- 6	-12	- 8	-323	-182	-39
0.20	+0.15g	- 6	-11	-13	-488	-319	-11
0.21		- 5	-11	-14	-512	-297	- 9
0.22		- 3	- 9	-12	-426	-211	- 9
0.23		- 4	-10	- 7	- 63	-126	-35
0.24		- 5	-11	- 8	-314	-169	-35
0.25	+0.05g	- 7	-10	- 6	-267	-196	-49
0.26		- 7	- 7	+ 5	+ 96	+152	-67
0.27		- 5	-10	-10	-380	-239	-22
0.28		- 2	- 6	-10	-350	-164	0
0.29		- 2	- 5	-11	-383	-169	+ 9
0.30	0	- 2	- 2	- 5	-185	-101	+22

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

4.

STRAIN AND STRESS DATA FOR THE MIDPOINT OF THE LONG EDGE OF THE FORWARD PANEL

Slam 6, Run 19, 11/22/58, 1800 RPM

Time	Al	ε_2(1)	σ_2(2)
0 SEC.	-0.40g	-12	-396
0.01		-25	-825
0.02		-30	-990
0.03		0	0
0.04		-12	-396
0.05	-0.40g	-10	-330
0.06		+30	+990
0.07		+25	+825
0.08		+43	+1410
0.09		+80	+2640
0.10	-0.20g	+100	+3300
0.15	+0.80g	*	
0.20	+1.25g		
0.25	+0.70g	*	
0.27		+115	
0.28		-12	-396
0.29		-90	-2970
0.30	+0.35g	+10	+330
0.31		+32	+1055
0.32		0	0
0.33		+45	+1485
0.34		0	0
0.35	+0.20g	-5	-166
0.36		-15	-495
0.37		-10	-330
0.38		0	0
0.39		0	0
0.40	+0.05g	+35	+1155
0.41		+15	+495
0.42		-10	-330
0.43		+25	+825
0.44		-20	-660
0.45	0	-33	-1090
0.46		-25	-495
0.47		+43	+1420
0.48		-5	-166
0.49		-25	-825
0.50	-0.10g	+20	+660

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

* - Strain exceeded the limit of the instruments (greater than 125 micro-inches per inch).

4. STRAIN AND STRESS DATA FOR THE MIDPOINT OF THE LONG EDGE OF THE FORWARD PANEL

Slam 7, Run 19, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_2^{(1)}$	$\sigma_2^{(2)}$
0 SEC.	-0.20g	-35	-1155
0.01		- 5	- 165
0.02		-35	-1155
0.03		-35	-1155
0.04		-11	- 363
0.05	-0.20g	-20	- 660
0.06		-30	- 990
0.07		-20	- 660
0.08		-20	- 660
0.09		-25	- 825
0.10	-0.20g	-22	- 726
0.11		-12	- 396
0.12		-21	- 693
0.13		- 8	- 264
0.14		-13	- 428
0.15	-0.10g	-17	- 560
0.16		0	0
0.17		0	0
0.18		-16	- 527
0.19		+20	+ 660
0.20	+0.10g	+20	+ 660
0.21		-40	-1320
0.22		-30	- 990
0.23		+25	+ 825
0.24		-25	- 825
0.25	+0.40g	-25	- 825
0.26		-15	- 495
0.27		-55	-1810
0.28		-55	-1810
0.29		-22	- 715
0.30	+0.25g	-20	- 660
0.31		-31	-1200
0.32		-10	- 330
0.33		-17	- 561
0.34		-28	- 925
0.35	+0.05g	-28	- 925
0.36		-20	- 660
0.37		-27	- 892
0.38		-12	- 396
0.39		- 5	- 166
0.40	0	- 7	- 231

4.

STRAIN AND STRESS DATA FOR THE CENTER OF LONG EDGE OF THE FORWARD PANEL (cont'd.)

Slam 7, Run 19, 11/22/58, 1800 RPM

Time	Al	ε_2 (1)	σ_2 (2)
0.41 SEC.	0	-10	- 330
0.42		-22	- 727
0.43		-32	-1055
0.44		- 7	- 231
0.45	0	-18	- 595
0.46		-18	- 595
0.47		- 5	- 166
0.48		- 2	- 66
0.49		-22	- 727
0.50	-0.05g	-20	- 660

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

4. STRAIN AND STRESS DATA FOR THE MIDPOINT OF THE LONG EDGE OF THE FORWARD PANEL

Slam 8, Run 19, 11/22/58, 1800 RPM

Time	Al	$\varepsilon_2^{(1)}$	$\sigma_2^{(2)}$
0 SEC.	-0.30g	-25	- 825
0.01		-37	-1220
0.02		-34	-1120
0.03		-32	-1055
0.04		-36	-1190
0.05	-0.30g	-30	- 990
0.06		-29	- 957
0.07		-20	- 660
0.08		-17	- 561
0.09		-24	- 792
0.10	-0.30g	- 5	- 165
0.11		0	0
0.12		0	0
0.13		+25	+ 825
0.14		+40	+1320
0.15	-0.05g	+30	+ 990
0.16		+35	+1155
0.17		+62	+2045
0.18		+73	+2410
0.19		+65	+2145
0.20	+0.25g	+40	+1320
0.21		+15	+ 495
0.22		+15	+ 495
0.23		0	0
0.24		- 7	- 231
0.25	+0.30g	0	0
0.26		0	0
0.27		-32	-1055
0.28		+ 8	+ 264
0.29		-17	- 561
0.30	+0.25g	-27	- 890
0.31		-25	- 825
0.32		-15	- 495
0.33		-20	- 660
0.34		-20	- 660
0.35	+0.20g	+ 5	+ 165
0.36		-15	- 495
0.37		-30	- 990
0.38		-13	- 429
0.39		-10	- 330
0.40	+0.05g	-20	- 660

4. STRAIN AND STRESS DATA FOR THE MIDPOINT OF THE LONG EDGE OF THE FORWARD PANEL (cont'd.)

Slam 8, Run 19, 11/22/58, 1800 RPM

Time	Al	ε_2 (1)	σ_2 (2)
0.41 SEC.	+0.05g	-20	-660
0.42		+ 3	+ 99
0.43		-10	-330
0.44		-15	-495
0.45	0	-10	-330
0.46		-20	-660
0.47		-15	-495
0.48		-18	-594
0.49		-19	-627
0.50	0	-10	-330

(1) - All strains are in micro-inches per inch.

(2) - All stresses are in pounds per square inch.

5. PEAK TO PEAK AMPLITUDE(1) OF STRAIN AND FREQUENCY(2) OF VIBRATION OF AFTER PANEL

3-Bladed Propellers

Run No.	RPM	Gage 1		Gage 2		Gage 5		Gage 6	
		Amp.	Freq.	Amp.	Freq.	Amp.	Freq.	Amp.	Freq.
6	1950	30	96	20	96	75	96	25	96
7	1800	20	88	50	88	75	88	20	88
		Gage 1		Gage 3		Gage 4		Gage 5	
1	1950	30	96	65	96	50	96	30	96
2	1600	15	88	55	88	40	88	20	88
3	1400	15	68	40	68	25	68	15	68

4-Bladed Propellers

		Gage 1		Gage 2		Gage 5		Gage 6	
5	1950	75	115	35	120	65	120	17.5	120
4	1800	65	115	21.5	115	50	115	15	115
3	1600	25	103	22.5	103	45	103	20	103
2	1400	15	96	12.5	96	17.5	96	9	96
1	600	0	-	0	-	2.5		5	
		Gage 1		Gage 3		Gage 4		Gage 5	
12	1950	40	124	50	124	Recorder Failed(3)		Recorder Failed(3)	
10	1800	40	116	60	116	70	116	50	116
11	1600	25	104	55	104	65	104	35	104
9	1400	20	96	35	96	45	96	20	96

(1) - All strain amplitudes in micro-inches per inch.

(2) - All frequencies of vibration in cycles per second.

(3) - Recorder stylus failed because of excessive amplitude of strain, value exceeded 125 micro-inches per inch in both tension and compression, or 250 micro-inches per inch peak to peak.

6.

THEORETICAL STRESS CALCULATED FROM PRESSURE DATA

SIMPLE SUPPORTED CONDITION

	SLAM A		SLAM D	
Time	P5	$(\sigma_x)_o$ (1)	P5	$(\sigma_x)_o$
0	-1.19	-9743	-0.84	-6877
0.05	-0.95	-7778	-0.96	-7860
0.10	-0.48	-3930	-0.60	-4912
0.15	+0.48	+3930	+0.47	+3848
0.20	+1.20	+9824	+2.88	+20303
0.25	+0.84	+6877	+4.00	+32748
0.30	0	0	+2.15	+17602
0.35	-0.48	-3930	+0.84	+6877
0.40	-0.84	-6877	-0.12	- 982
0.45	-1.10	-9005	-0.48	-3930
0.50	-1.32	-10807	-0.48	-3930

(1) - $(\sigma_x)_o$ is the transverse stress at the center of the panel.

7.

THEORETICAL STRESS CALCULATED FROM PRESSURE DATA

MEMBRANE ANALYSIS

	SLAM A				SLAM D			
Time	P5	$P^{2/3}$	$(\sigma_x)_o^{(1)}$	$(\sigma_x)_{a/2}^{(2)}$	P5	$P^{2/3}$	$(\sigma_x)_o^{(1)}$	$(\sigma_x)_{a/2}^{(2)}$
0	-1.19	1.0117	2812	3925	-0.84	0.890	2474	3453
0.05	-0.95	0.9664	2687	3750	-0.96	0.973	2705	3775
0.10	-0.48	0.612	1701	2374	-0.60	0.711	1977	2759
0.15	+0.48	0.612	1701	2374	+0.47	0.604	1679	2343
0.20	+1.20	1.1128	3093	4318	+2.88	2.020	5615	7838
0.25	+0.84	0.890	2474	3453	+4.00	2.520	7056	9778
0.30	0	0	0	0	+2.15	1.637	4531	6324
0.35	-0.48	0.612	1701	2374	+0.84	0.890	2474	3453
0.40	-0.84	0.89	2474	3453	-0.12	0.243	676	943
0.45	-1.10	1.0656	2962	4135	-0.48	0.612	1701	2374
0.50	-1.32	1.204	3347	4672	-0.48	0.612	1701	2374

(1) - $(\sigma_x)_o$ is the transverse stress at the center of the panel.

(2) - $(\sigma_x)_{a/2}$ is the stress at the middle of the long edge.

APPENDIX "C"

CALCULATIONS

1. Smooth Planing Pressure Distribution (NACA TN 2583)

Theoretical

Data:

At 1950 RPM

$\bar{f}$ = planing velocity = 33.78 ft.

τ = trim angle = 6°

λ_p = wetted length = 29.0 lb.

b = beam at this location = 8.50 ft.

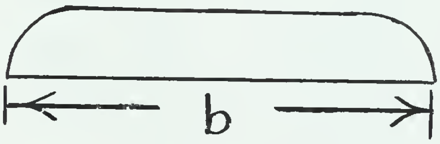
Calculations:

(1) From figure 9, page 25

For $\lambda_p = \frac{29.}{8.5} = 3.4$ beams $C_{NP} = 0.052$

$\tau = 6^{\circ}$

(2) $\frac{\bar{P}}{Pc} = 0.95$



Transverse Distribution

Therefore

$$(C_{NP})_c = \frac{C_{NP}}{0.95} = \frac{0.052}{0.95}$$

$$(C_{NP})_c = 0.0546$$

(3) Longitudinal Pressure Distribution 1 from figure 4, page 21

$$\frac{P_c}{1/2 \ f^2} = f\left(\frac{\lambda}{\lambda_p}\right)$$

P_o = longitudinal pressure distribution

$P_o = 0.95 \ P_c \times b$

λ/λ_p	$p_c/\frac{1}{2}\rho\dot{f}^2$	λ/λ_p	$p_c/\frac{1}{2}\rho\dot{f}^2$
0	0	0.6	0.040
0.1	0.01	0.7	0.050
0.2	0.015	0.8	0.068
0.3	0.020	0.9	0.100
0.4	0.025	0.95	0.140
0.5	0.031	1.00	1.000

Stagnation pressure $= \frac{1}{2}\rho\dot{f}^2 = \frac{1.99}{2}(33.78)^2$

$= 1135$ psf

λ/λ_p	λ	$p_c/\frac{1}{2}\rho\dot{f}^2$	p_c	b	$0.95b$	p_o	S.M.	F(A)	ARM	F(M)
0.0	0	0	0	0	0	0	1	0	10	0
0.1	2.9	0.01	11.35	9.50	9.03	102	4	408	9	3672
0.2	5.8	0.015	17.00	9.50	9.03	154	2	308	8	2464
0.3	8.7	0.020	22.70	9.66	9.18	208	4	832	7	5824
0.4	11.6	0.025	28.37	10.20	9.69	275	2	550	6	3300
0.5	14.5	0.031	35.19	10.34	9.82	346	4	1384	5	6920
0.6	17.4	0.040	45.40	10.25	9.74	442	2	884	4	3536
0.7	20.3	0.050	56.75	10.20	9.69	550	4	2200	3	6600
0.8	23.2	0.068	77.18	10.00	9.50	733	1	1099	2	2198
0.85	24.65	0.080	90.80	9.75	9.26	841	2	1682	1	2523
0.90	26.1	0.100	113.50	9.50	9.03	1025	1	1025	1	1025
0.95	27.55	0.140	158.90	8.82	8.38	1332	2	2669		1332
1.00	29.00	1.00	1135.00	8.50	8.08	9170		4583	0	0
								Σ 17619		Σ 39324

$$\text{Force} = \frac{2.9}{3} \times 17619$$

$$\text{Force} = 17032 \text{ lbs.}$$

$$= \frac{S\ \ F(m)}{F(A)}$$

$$= \frac{2.90 \times 39324}{17619} = 6.473 \text{ ft. from entry}$$

$$= 22.527 \text{ ft. forward from transom } ^{\circ}F$$

Recorded Pressure In Slamming

For slamming condition we recorded P_c at three different longitudinal locations. $\frac{P}{P_c} = 0.50$ $P_o = \quad x\, b = \frac{1}{2} P_c\, b$

	P_c psi	P_s pst	b/2 ft	P_o lb/ft	wt from Transom
P4	2.98	429	4.50	1930	27.3 ft.
P5	5.57	802	4.75	3810	25.5 ft.
P6	1.45	209	5.00	1045	23.3 ft.

These points were plotted on page 10 in order to compare the values with normal planing condition.

2. Static Displacement

Data:

The drafts were known by taking the distance from the sheerline to WL at rest.

Drafts referred to the basc line (*) were:

At Station 3: 3'6"

At Station 5: 3'4"

At Station 8: 3'0"

(*) - USCG Plan No. 40-UT-0103-10

From the (*) we got the sectional areas, and from here we got the total Δ of the boat and the position of the center of gravity.

Δ CALCULATIONS

ORD	VAL	Fs	F(v)	Arm	F(M)
0	4.85	1	4.85	0	0
1	6.10	4	24.40	1	24.40
2	8.00	2	16.00	2	32.00
3	10.50	4	42.00	3	126.00
4	12.50	2	25.00	4	100.00
5	13.05	4	52.20	5	161.00
6	12.90	2	25.80	6	154.80
7	11.50	4	46.00	7	322.00
8	7.60	2	15.20	8	121.60
9	3.50	4	14.00	9	126.00
10	0	1	0	10	0

$$\Delta = \frac{S}{3}\Sigma_1 = \frac{3.8}{3} \times 265.45$$

$$\Delta = 336.23$$

$$\Delta = \nabla \times \rho = 336.23 \times 64$$

$$\Delta = 21518.78 \text{ lbs.}$$

= Dist. of CG from transom $\bar{x}$:

$$\bar{x} = \frac{S\Sigma_2}{\Sigma_1} = \frac{3.8 \times 1267.80}{265.45}$$

$$\bar{x} = 18.146 \text{ ft.}$$

Boat Δ = 21518 lbs.

Dist. CG from Transom = 18.146 ft.

(*) - USCG Plan No. 40-UT-0103-10

3. Buoyancy Data at 1900 RPM

The boat is down by the bow at rest by

$$\psi = \text{tangent}^{-1}\ \frac{13.5}{480} = \text{tangent}^{-1}\ 0.0281$$

$$\psi = 1°37'$$

This data was taken from draft readings.

The approximate trim angle at 1900 RPM is 6°t

The mean planing waterline was developed from photographs of the boat at 1950 RPM and also from observations as to the entry point and draft aft at speed.

The mean trim angle = $\text{tangent}^{-1}\ \frac{27''}{(29\text{x}12)''} = \text{tangent}^{-1}\ 0.07759$.

Mean trim angle = 4°26'. To this we add the trim by bow at rest since our zero point is that angle.

Indicated trim angle	6°+
Actual trim angle	6°03'

Developing buoyancy from the sectional areas (immersed) by placing a wave train as near to that observed as possible over the mean trim planing waterline: (1' peak to trough). See Fig. 6

Sta.	Dist. from Transom	Sect. Area
BH4	26.5'	0.92 ft^2
BH6	22.5'	5.14 ft^2
Fr10	14.5'	6.19 ft^2
Fr15	6.00'	4.48 ft^2
Transom	0	11.39 ft^2

Buoyancy at 1900 RPM with Observed Wave Train

ORD	VALUE	SM	FV	ARM	FM
0	11.4	1	11.4	0	0
1	7.0	4	28.0	2	56
2	5.4	2	10.8	4	43.2
3	4.4	4	17.6	6	105.6
4	4.8	2	9.6	8	76.8
5	5.5	4	22.0	10	220
6	6.0	2	12.0	11	132
7	6.4	4	25.6	14	358.4
8	6.5	2	13.0	16	208
9	6.4	4	25.6	18	460.8
10	6.0	2	12.0	20	240
11	5.2	4	21.6	22	475.2
12	3.6	2	7.2	24	172.8
13	1.5	4	6.0	26	156
14	0.3	1	0.3	28	8.4
Σ			222.7		2713.2

$$V = 222.7 \times \frac{2}{3} = 148.47 \text{ ft}^3 \times 64 = 9502.1 \text{ lb.}$$

CB = FM/FV = 12.18 ft. Fwd of Transom

Moments About Transom

Clockwise: 21,518 lb. x 18.15 ft. = 390,552 Weight

Counterclock: 9,502 lb. x 12.18 ft. = 115,734 Buoyancy

274,818 Dynamic

Dynamic Force = 21,518 - 9,502 = 12,016.

Center of Pressure $= \frac{274,818}{12,016} =$ 22.87 ft. Fwd. Transom

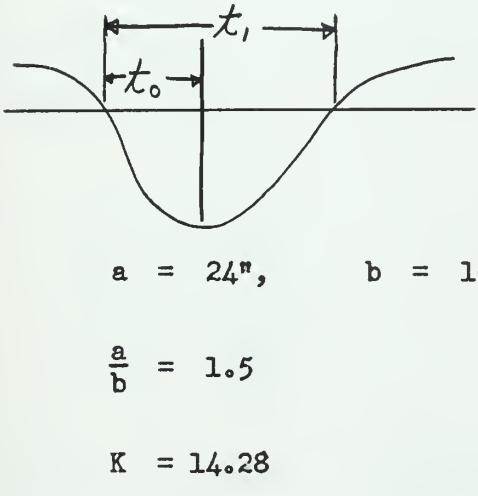
Buoyancy $= \frac{9502}{21,518} = 44.16\%$

Dynamic $= \frac{12,016}{21,518} = 55.84\%$

4. Calculation of Stresses From Pressures on Forward Plate

(a) Dynamic load factor at P5 by method of (10), pages 4-7.

From the data of slam F, run #23, 10/4/58, at a speed of 1800 RPM;



t_o = 0.06 second

t_1 = 0.18 second

a = 24", b = 16", t = 0.1225"

$\frac{a}{b} = 1.5$

K = 14.28

$$f_n = 9730 \frac{Kh}{a^2} = \frac{9730(14.28)(0.1225)}{(16)^2} = 66.5 \text{ cps}$$

$$T = \frac{1}{f_n} = \frac{1}{66.5} = 0.015 \text{ second}$$

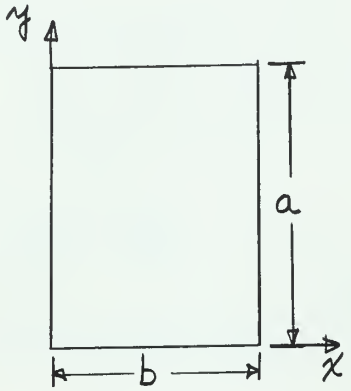
$$\frac{t_1}{T} = \frac{0.18}{0.015} = 12.0$$

By using figure 3 of (10), page 7,

For $\frac{t_o}{T} = \frac{0.16}{0.015} = 4.0$, the magnification factor for our boat equals 1.0.

(b) Stress Evaluation, Fixed Edges

From the pressure values we can estimate the stresses for fixed edges by (22), page 286.



$$(M_x)_{x = 0,\ y = a/2} = -\beta_1 pb^2$$

$$(M_x)_{x = b/2,\ y = a/2} = \beta_2 pb^2$$

β_1 and β_2 are coefficients given as a function of $\frac{a}{b}$ in figure 7.3, page 286 of (22).

$$\frac{a}{b} = 1.5$$

$$\beta_1 = 0.076$$

$$\beta_2 = 0.037$$

$$\sigma_x = \frac{6M_x}{t^2}$$

$$(\sigma x)_{x = 0,\ y = a/2} = \frac{6(-0.076)(16)^2 p}{(0.1225)^2} = -7780p$$

$$(\sigma x)_{x = b/2,\ y = a/2} = \frac{6(0.037)(16)^2 p}{(0.1225)^2} = 3780p$$

For the highest pressure recorded, 5.16 psi,

$$(\sigma x)_{x = 0,\ y = a/2} = -7780(5.16) = -40{,}100 \text{ psi.}$$

$$(\ x)_{x = b/2,\ y = a/2} = 3780(5.16) = 19{,}500 \text{ psi.}$$

The tabulation of values calculated are found in Appendix B2.

(c) Stress Evaluation, Simply Supported Edges

From the pressure values we can estimate the stresses by (22), page 285.

$$(M_x)_{x = b/2,\, y = a/2} = \beta p b^2$$

β is given as a function of $\frac{a}{b}$ in figure 7.2, page 285.

$$\frac{a}{b} = \frac{24}{16} = 1.5$$

$$\beta = 0.08$$

$$(\sigma_x)_{o} \quad x = b/2,\ y = \frac{a}{2} = \frac{6M_x}{t^2} = \frac{6(0.08)(16)^2 p}{(0.1225)^2} = 8{,}187p$$

For the highest pressure recorded, 5.16 psi,

$$(\sigma_x)_{x = b/2,\, y = a/2} = 8{,}187(5.16) = 42{,}245 \text{ psi.}$$

The tabulation of values calculated are given in Appendix B2.

(d) Stress Evaluation, Membrane Analysis

From the pressure values we can estimate the stresses by (22), pages 288-290.

$$(\sigma_x)_{x = 0,\, y = a/2} = n_6 \sqrt[3]{p^2 E \frac{a^2}{t^2}}$$

$$(\sigma_x)_{x = b/2,\, y = a/2} = n_2 \sqrt[3]{p^2 E \frac{a^2}{t^2}}$$

n_2 and n_6 are given as a function of $\frac{a}{b}$ in figure 7.5, page 290.

$$\frac{a}{b} = 1.5, \quad n_6 = 0.370, \quad n_2 = 0.265$$

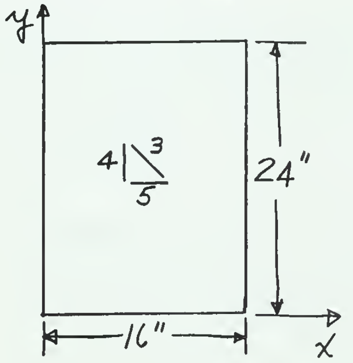
For the highest pressure recorded, 5.16 psi,

$$(\sigma x)_{x = 0,\ y = a/2} = 0.370 \sqrt[3]{\frac{30(10^6)(24)^2(5.16)}{(0.1225)^2}} = 11{,}550 \text{ psi.}$$

$$(\sigma x)_{x = b/2,\ y = a/2} = 0.265 \sqrt[3]{\frac{30(10^6)(24)^2(5.16)}{(0.1225)^2}} = 8{,}260 \text{ psi.}$$

5. Calculation of Stresses From Strain Data

(a) Center of panel, σx



$$\varepsilon x = \varepsilon_5$$

$$\varepsilon y = \varepsilon_4$$

$$\sigma x = \frac{\varepsilon x + \mu \varepsilon y}{1 - \mu^2}$$

$$\mu = 0.3$$

The tabulation of values calculated are given in Appendix B3.

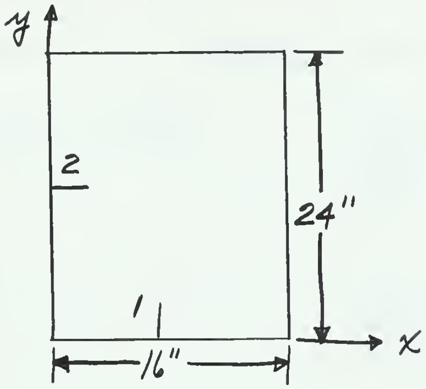
(b) Center of panel, maximum principal stress

$$\sigma_{max.\ prin.} = \frac{E}{2}\left[\frac{\varepsilon_4 + \varepsilon_5}{1-\mu} + \frac{\sqrt{(\varepsilon_4 - \varepsilon_5)^2 + [2\varepsilon_3 - (\varepsilon_4 + \varepsilon_5)]^2}}{1+\mu}\right]$$

$$\tan 2\phi = \frac{2\varepsilon_3 - (\varepsilon_4 + \varepsilon_5)}{\varepsilon_4 - \varepsilon_5}$$

The tabulation of values calculated are given in Appendix B3.

(c) Edge of panel, σ_x



$$\varepsilon_x = \varepsilon_2$$

$$\varepsilon_y = \varepsilon_1$$

$$\sigma_x = \frac{\varepsilon_x}{1 - \mu^2}$$

$$\mu = 0.3$$

The tabulation of values calculated are given in Appendix B4.

6. Determination of the Natural Frequency of After Panel

$$F = 9730 \frac{Kh}{a^2}$$

K = frequency number for plate. This is a function of $\frac{b}{a}$ and end support condition.

h = plate thickness in inches. $a = 12''$, $b = 15''$

a = short side in inches. $\frac{b}{a} = \frac{15}{12} = 1.25$

For simple edge support:

$$F = \frac{9730(16.7)(0.1225)}{144} = 138$$

For fixed edge condition:

$$F = \frac{9730(30.7)(0.1225)}{144} = 254$$

7 Calculation of Frequency Ratio for 3 and 4-Bladed Propellers

No.of Blades	Simple Support	Fixed Edges
3	$\frac{96}{138} = 0.695$	$\frac{96}{254} = 0.378$
4	$\frac{120}{138} = 0.870$	$\frac{120}{254} = 0.472$

APPENDIX "D"

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